REPORT RESUMES

ED 016 400 24 EM 005 985
VISUAL AND AUDIO PRESENTATION IN MACHINE PROGRAMED
INSTRUCTION. FINAL REPORT.
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REPORT NUMBER BR-5-0724 PUB DATE JAN 67
CONTRACT OEC-3-10-084
EDRS PRICE MF-$1.00 HC-$9.24 229P.

DESCRIPTORS- *PROGRAMED INSTRUCTION, *RESEARCH DESIGN, *INDIVIDUAL DIFFERENCES, *EXPERIMENTS, *PROGRAM CONTENT, STATISTICAL ANALYSIS, INTELLIGENCE QUOTIENT, ETHNIC GROUPING, LITERATURE REVIEWS, LINEAR PROGRAMING, AURAL STIMULI, VISUAL STIMULI, TEACHING MACHINES, SEX (CHARACTERISTICS)

THIS STUDY WAS PART OF A LARGER RESEARCH PROGRAM AIMED TOWARD DEVELOPMENT OF PARADIGMS OF MESSAGE DESIGN. OBJECTIVES OF THREE PARALLEL EXPERIMENTS WERE TO EVALUATE INTERACTIONS OF PRESENTATION MODE, PROGRAM TYPE, AND CONTENT AS THEY AFFECT LEARNER CHARACTERISTICS. EACH EXPERIMENT USED 18 TREATMENTS IN A FACTORIAL DESIGN WITH RANDOMLY SELECTED GROUPS OF ABOUT 400 GRADE 8 STUDENTS EACH. AUDIO PRESENTATION MODES WERE--SILENT, REDUNDANT, DIRECTIVE. VISUAL MODES WERE--PRINTED VERBAL, STILL GRAPHIC, MOTION PICTURE. PROGRAMS WERE LINEAR AND BRANCHING. PROGRAM CONTENT (ON THE SUBJECT "CRYSTALLOGRAPHY") INVOLVED NON-CONCRETE REFERENTS (SUCH AS SPELLING OF WORDS), CONCRETE REFERENTS (THOSE DESCRIBABLE BY PICTURES), AND ACTION-PROCESS (CONTINUOUS ACTION SEQUENCES). CONTENT WAS HELD CONSTANT IN EACH EXPERIMENT. EQUIPMENT AND STUDENT SELECTION FACTORS WERE CAREFULLY CONTROLLED. IMMEDIATE POST-TEST SCORES ON FOUR DIFFERENT MEASURES WERE STATISTICALLY ANALYZED, AND SEVERAL SIGNIFICANT RELATIONSHIPS FOR SPECIFIC CONDITIONS EMERGED. HOWEVER, NO CONSISTENT PATTERNS OF SUPERIORITY FOR ANY RELATIONSHIPS BETWEEN VISUAL, AUDIO, OR PROGRAMING VARIABLES WERE DEMONSTRATED, WITH ONE EXCEPTION. FUTHERMORE, FEW CONSISTENT RELATIONSHIPS BETWEEN PRESENTATION MODES AND LEARNER CHARACTERISTICS WERE FOUND. ONE MAJOR CONCLUSION OF THE EXPERIMENTS WAS THAT EVEN UNDER SELECTED CONDITIONS, A RELATIONSHIP COULD BE DEMONSTRATED BETWEEN CONTENT AND PRESENTATION MODE. (LH)

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FINAL REPORT
Project No. 5-0724-2-12-1
Contract No. OE-3-10-084

Visual and Audio Presentation in Machine Programed Instruction

January 1967

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Office of Education
Bureau of Research

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VISUAL AND AUDIO PRESENTATION IN MACHINE PROGRAMED INSTRUCTION

Project No. 5-0724-2-12-1
Contract No. OE-3-10-084

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January 1967

The research reported herein was performed pursuant to a contract with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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EM 005 925

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ACKNOWLEDGMENTS

The performance [illegible] this project would have been impossible without [illegible] participation and cooperation of a number of individu[illegible] and schools.

Special appreciation is extended to the principals and staffs of Orville Wright Junior High School, John Muir Junior High School, Henry Clay Junior High School, and Thomas Starr King Junior High School in the Los Angeles Unified School District, to the Culver City Junior High School, and to McKinley Junior High School in Pasadena. These schools made their facilities and students available over a prolonged period of time and participated in either the tryout phase or the experimental phase of the project.

Involved in different parts of the study, in addition to the authors of the report, were members of the faculty and staff of the University of Southern California. Donald G. Perrin designed the teaching machine system used in the study and brought it to the operational level. Genevieve Gray played a major role in the preparation of the programs for the first two experiments. Herbert Kosower, David W. Johnson, Richard Harber, Daniel Wiegand, Ken Miura, and Herbert Farmer, all of the University of Southern California Cinema Department faculty, made possible the production of the experimental programs. Arthur Phelps, Robert Heinich, Christine Heinich, Royd Weintraub, Vera Chow, Gertrude Langerud, Patricia Shirek, Sharon Johnson, and Maureen Walsh made valuable contributions to the project. Donald Estavan, of the System Development Corporation, assisted in the preparation of the criterion tests.

CHAPTER I

INTRODUCTION

This study was conceived and conducted as a pilot investigation of a number of specific factors used in the design and production of instructional messages for presentation as machine-mediated programed instructional sequences. It was directed toward the discovery of interrelationships among stimulus presentation variables, the nature of the content being taught, and various characteristics of the learner. Thus, it was hoped that the study would (1) make some contributions to our knowledge of the conditions under which programed instructional materials could be designed so as to enhance their instructional impact and (2) suggest directions for future research on the message design variables being investigated.

The Problem

The major problem of the study was to investigate the instructional effectiveness of three different modes of visual presentation, three different modes of audio presentation, and two forms of programed instruction when used with subject matter content having three inherently different characteristics. A secondary problem was a determination of the relationships of these variables to specified learner characteristics.

It was postulated that the modes of presentation of programed materials would have differential effects upon the acquisition of knowledge and its application. It was further postulated that the learning of different kinds of subject matter content would vary according to the kind of stimulus presentation mode employed. Finally, it was postulated that the learning would vary differentially for the various visual presentation modes according to certain characteristics of the learners. The study of these problems was rooted in the supposition that the effectiveness of instructional materials is a function of the interactions between the stimulus presentation techniques employed and/or (1) the inherent nature of the subject matter content being taught, (2) the characteristics of the learner, and (3) the classroom teaching procedure used. This study investigated the first two of these interactions, controlling for the classroom teaching procedure by exposing all subjects to the same classroom environmental conditions: student-paced, machine-presented stimuli in an individual learning booth.

Specifically, three parallel experiments were conducted with eighth grade students, each employing inherently different subject matter content in the science subject of "crystallography." The three types of content were: (1) material characterized as possessing a maximum of "non-concrete referents" and a minimum of "concrete referents" in the subject matter presented, (2) material with a maximum of "concrete referents" and a minimum of "non-concrete referents," and (3) material consisting of the presentation of "actions" and "processes." Each content area was prepared as programed learning sequences for machine presentation employing a combination of three "visual presentation modes" (printed-verbal, printed-verbal supplemented by still pictures, and printed-verbal supplemented by the pictures presented in motion), three "audio presentation modes" (silent with no sound, redundant sound repeating the printed material, and directive sound pointing out relevant cues in the visual presentations), and two forms of "programed instruction" (the step-by-step linear approach giving the subject immediate feedback as to the correctness of his response and the remedial branching approach giving the subject opportunities to receive remedial instruction when an incorrect response was made).

The study was important in that it was one of the first attempts to investigate relationships between modes of presentation of instructional materials and the characteristics of those materials themselves. In addition, it studied the relationships of various learner characteristics to these variables. By replicating the design in three separate experiments, generalizations were more credible. Finally, the study was intended to be a broad, multi-variable pilot study that would be more suggestive of useful future research directions than of definitive answers to the questions posed. The study was part of a broader program of research directed toward the development of paradigms of instructional message design as related to an emerging science of instruction.

CHAPTER II

REVIEW OF LITERATURE

The literature and research will be reviewed in five sections, each treating a class of variables related to the problems under study: visual presentation techniques, audio implementation, programing approach, content inherency factors, and specific learner characteristics.

Visual Presentation Techniques

Although there is a dearth of previous experimental research bearing directly on the question of the relative effectiveness of the various pictorial-verbal stimulus modes in machine-mediated programed instruction, there is a long history of audiovisual communication research presenting evidence as to the overall instructional values of both still and motion picture visual presentations. Allen (1960) and Hoban and van Ormer (1950), after intensive reviews of audiovisual research, concluded that motion picture films and filmstrips were at least as effective as conventional modes of instruction in teaching factual information and concepts.

In an attempt to determine more precisely the conditions under which learning by means of visual or pictorial presentations could be enhanced, Lumsdaine (1958) studied the role of pictures and words in associative learning of verbal responses. He found that, for both junior high school and college students, pictures of objects placed in a stimulus position showed a significant superiority over printed words in that position in eliciting the desired response. These results were confirmed by Kopstein and Roshal (1961), who found that picture-word combinations were superior to word-picture combinations in teaching Russian vocabulary, and by Kale and Grosslight (1955), who found that presentations with pictures (motion pictures for verbs and still pictures for nouns in teaching the Russian language) were more effective than presentations without pictures. Gropper (1965) presented further evidence, in two studies on controlling student responses during visual presentations of programed eighth grade general science instruction, that supported the above findings. He concluded that science concepts were more easily acquired on the basis of discrimination practice to visual demonstration events than on the basis of verbal lesson materials, that transfer from one learning experience to another was more likely to occur when a pictorial-verbal order of presentation was used, and that transfer across modes was more likely to occur from the learning situation to the testing situation when learning was based on visual experiences.

Recently, several researchers have pointed out the possible interference effects to learning resulting from simultaneous media presentation in more than one channel. Krauser (1962) found that integrated programed instruction, in which verbal and pictorial materials were combined, may have interfered with relational reasoning and resulted in lower program effectiveness than either the verbal or pictorial presentation modes alone. Travers' (1964a, 1964b) findings also suggested that such interference could occur to inhibit learning. The present study combined verbal and visual material in such a way that possible interference effects could be subjected to further examination.

Audio Implementation

As was the case with pictorial presentation techniques, practically no research had been conducted directly pertaining to the relationship between programed instruction and the type of audio accompaniment used. Yet various facets of audio implementation of visual presentations have been studied, with conflicting results. Hartman (1961), in a comprehensive review of research bearing on single and multiple-channels of presentation, reported evidence favoring simultaneous multiple-channel presentation (audio-print, audio-pictorial, pictorial-print, and audio-pictorial-print) over single-channel presentations of print, pictures, or audio alone. However, Travers (1964a, 1964b) elicited evidence that presentation in audio and visual channels simultaneously might interfere with learning, concluding that "no advantage is achieved by transmitting redundant information simultaneously through both the auditory and visual modality, except where unusually high speeds of transmission are involved." However, such simultaneous presentation reported by Travers was that presented under laboratory conditions in which the simultaneity was extremely precise. The question was still unanswered as to the possible interference between channels resulting from the kinds of simultaneity of presentation occurring in sound motion pictures, wherein the viewer-listener had adequate time to scan successively both the visual and the audio channels. The present study presented further evidence relative to this question.

The research evidence relating to the use of the audio narration to "direct" the learner to attend to specified visual cues was also contradictory (Allen, 1960; Hoban & Van Ormer, 1950; Lumsdaine, 1963). Zuckerman (1949) found, with a military population, that directive statements in the film commentary were more effective in promoting motor skill learning than third person passive-type statements, but Neu (1950) and Lumsdaine and Gladstone (1958) failed to find significant effects when they used audio and visual attention-gaining devices to arouse attention.

Self-Pacing as a Function of the Audio Stimulus

The question of pacing was particularly relevant to this study as pacing was a feature of the audio versions of the programed materials. Pacing was also closely related to a measure of repetition since it dealt with the amount of content covered per unit of time. Each redundant sound version provided audio content comparable to the verbal content provided on the student's viewing screen. Audio versions in the directive sound also provided content but only on a random schedule. It was observed by the experimenters that many students interpreted the cessation of the sound accompanying a frame as a "signal" to proceed to the next frame. One could interpret the conditions, therefore, as a method for forced-pacing in contrast to self-pacing by students in the non-audio treatments. Follettie (1961) reported that self-pacing, as opposed to forced-pacing, resulted in both a superior performance post-test score and shorter time required to complete the program. Maccoby and Sheffield (1958) reported that, in dealing with high school and undergraduate students, a self-pacing procedure worked best for superior students. The stimulus material used by these researchers was a filmed demonstration of an assembly task.

Other researchers have reported no real differences between pacing and non-pacing. Most relevant to this study was the work of Moore and Smith (1961). They introduced 35 sixth graders to the use of a program where some students worked at their own speeds while others were required to complete a specified number of units each week. Similarly, Alter and Silverman (1962) found that 60 university students, involved in pacing vs. self-pacing groups while completing a program in basic electricity, did not record significantly different post-test scores. Briggs, Plashinski, and Jones (1955) reported that 77 airmen when compared in a self-paced vs. an automatic paced group recorded no significant difference when post-test results were examined. Carpenter and Greenhill (1963) supported this finding in a study conducted with 180 college mathematics students. Pacing was varied as much as 20 percent below and 10 percent above the average time required by a group of self-paced students, with no significant difference reported in student performance or attitude. In another experiment in this same study, external pacing and self-pacing treatment groups reflected no significant differences in learning outcomes.

Programing Approach

Linear and Branching

Comparisons of linear and branching programs, as methods of adapting to individual differences, have concerned researchers in programed instruction since 1959. Mager (1961) noted greater post-test gains for a linear over a branching group, but these gains involved a longer training time for the completion of the linear program that involved a calibration task. Reynolds and Glaser (1962) also obtained results supporting the linear approach. Comparisons of linear programing and one method of spaced-review programing (review branches) in general science were made under conditions of a fixed amount of learning time and a fixed amount of material presented. In the fixed-time condition, the seventh graders in the linear group showed significantly greater gains in achievement than the review group. Retention was equivalent for both groups over a 15-week period. Although the review program was referred to as a spiral program, it actually provided required review branches for the students at the end of each unit. When a fixed material condition was used the groups showed equivalent achievement, but the "spiral-branching" group took longer to cover the same amount of material. Beane (1962), in a comparison of linear and branching plane geometry programs, discovered that although the branching program used was more efficient than the linear, students expressed attitudes more favorable to the linear programs following completion of the study.

Coulson and Silberman (1960) compared a fixed item sequence with a variable sequence in which some items were skipped by students who made no errors. The subjects with a limited form of "skip-ahead" branching learned as well as students in the fixed sequence, and also learned in a shorter time. Branching depended entirely on the errors made on individual items and the student did not make the decision as to whether he would "branch" or not. In a follow-up study, Silberman and others (1961) explored the effectiveness of a fixed-sequence program as contrasted to the program presented in textbook format. The textbook method, which allowed for "random" branching was superior to the fixed-sequence or to a back-branching treatment that allowed for review of previous material, one item at a time. The back-branching procedure did not prove to be superior to the fixed-sequence version. The second experiment in this 1961 study employed a computer-controlled teaching machine to evaluate the effectiveness of adapting sequences of the same logic program. No significant differences were obtained between the branching and fixed-sequence groups. Low aptitude subjects in both groups failed to learn much of the material. The branching sequences used did not go very far in accommodating to individual differences. In a sequel to the foregoing, Coulson (1961) modified the remedial items and the branching structure of the logic program. These modifications resulted in superior learning by the branching group. Branching was based entirely on errors made, and the wishes of the student did not determine which branches were presented as part of the sequence. Error rate within a segment was used as the branching criterion.

In contrast to studies which pointed out advantages for either the linear or branching modes, several studies reported no significant differences between the two techniques.

Campbell (1961) and Roe (1962) compared branching programs with linear programs and found no significant differences on post-tests. Roe also compared a branch before the main diagnostic item (backward branching) to one placed after the diagnostic item (forward branching) and found forward branching more effective. Campbell (1962), in a series of studies dealing with bypassing (skip the branch if correct response is made) as a way of adapting self-instruction programs to individual differences, explored the effectiveness of forward branching and also reported no significant differences. Glaser (1964) reported that in an evaluation of multiple tracks in a linear program no significant difference was obtained between the various treatments.

Review as a Function of Branching

The question of whether there are opportunities to review material while going through a program is closely related to any discussion of a linear-branching dichotomy. Holland and Porter (1961) permitted undergraduate college students to repeat items in a program which were missed on the first try. Use of this short form of a "branch" was followed by a record of fewer errors, as contrasted to students without the option, on both an immediate and delayed criterion test. Ferster (1961) required students in his study to repeat the entire first 61 lessons of this same program. He obtained no significant difference in post-test results between the single trial and repetition group. If Ferster's assumption that the required review was already built into the program is correct, an important question is raised. How much more review material _is_ provided in branching programs, such as those being reported in the present study, as compared to strict linear programs? Is there an innate dissimilarity of exposure to content because of different review possibilities?

Rothkopf (1961) used different content to approach the review question in a different fashion. One hundred airmen were provided eight paired-associate items. In one version an item was dropped after one correct response, in the second version each item was dropped out only after two correct responses. In this fashion the researcher examined the effects of different amounts of review on post-test results. No significant differences were found between the two methods of adjusted learning. Even more closely related to the student population and program content being considered in this study is the work of Reynolds and Glaser (1963). In three experiments using biology programs with junior high school students, they explored the problems of repetition and spaced review. Spacing of review sequences throughout the content aided retention for all groups exposed to this treatment. This finding was corroborated by the work of Silberman *et al.* (1964). However, Reynolds and Glaser found that repetition alone was not demonstrated to be a major variable influencing the retention of complex subject matter.

Content Inherency Factors

No research has been located that bears on the relevance of the presentation mode to the inherent characteristics of the subject matter content being taught. The only relevant literature is that by Gagné (1962, 1965), Gagné and Bolles (1959), and Parker and Downs (1961). They have attempted to analyze the various learning task variables and, in some cases, to determine the most appropriate instructional media to use in teaching under the specified conditions.

Specific Learner Characteristics

This section reports the research literature regarding the relationships of learner characteristics to the major variables under study.

Learner Characteristics and Programed Instruction

Jensen (1963) reported assessments of learning ability using programs with junior high school students designated as retarded, average, and gifted. Variability was much greater among the retarded youngsters who, nevertheless, showed much greater improvement with practice on successive forms of the learning task; some of these retarded subjects learned as fast as the gifted. Bivens, Campbell and Terry (1963), among others, also indicated that programs may be used successfully with low ability students. The successful utilization of programs for special education was also demonstrated by Smith and Quackenbush (1960), Price (1962), Lippert and Stolurow (1963), and Blackman and Smith (1964). Thus, it would seem clear that junior high school students with many different characteristics, do learn from programed instructional materials.

Perception of Non-Verbal Stimuli

Learning gains made by students who were presented with non-verbal, as contrasted to verbal, materials was directly related to how well students perceived shapes and forms. The complexity of predicting performance or perception was indicated most clearly by several factor analyses of perceptual performance. Among these were the analyses of Thurstone (1944), Guilford and Lacey (1947), and Roff (1952). These authors noted many different perceptual factors that needed to be considered, including closure, reaction time, perceptual speed, judgmental speed, directional thinking, length perception, sequential perception, complex reaction time, visual memory, paired associates memory, reproductive memory, and memory for name-object associations. This constellation of factors indicated that perception of visual shapes and forms was a complex task.

Dawson (1964) obtained data to support the assumption that individuals differ in their abilities to recognize and to learn from certain graphic configurations. He reported that college students who scored high on figural portions of the Guilford-Zimmerman Aptitude Survey also were more successful in recognizing figural configurations than those who scored low on the Survey. On the other hand, Gagne and Gropper (1964) examined individual differences of eighth graders in learning from visual and verbal presentations and found no correlations between spatial aptitude and learning with pictorial representations. However, some evidence was revealed to support the contention that higher relationships occur between verbal aptitude and learning with the verbal presentations than with the visual presentations.

A relatively large number of studies have been concerned with age changes as this factor related to organizational ability in the perceptual realm. Among these were Balinski (1941) Dodwell (1961), Dragons and Multari (1961), Gibson et al. (1962), Rajalakshmi (1963), and Wohlwill (1960). The general outcome of these studies could be grouped into three categories: (1) generalization or specialization of abilities seemed to remain remarkably uniform with age,

(2) abilities appeared to become more generalized the older the individual, and (3) a trend toward differentiation was evident up to a certain age followed by a reverse trend toward greater generalization thereafter. Supporting the findings of the foregoing researchers was a series of recent studies (Otto, 1962, 1964) whose conclusions indicated that children and adults responded differently to verbal and non-verbal (pictorial) presentations of the same stimuli. Otto (1964) was able to obtain a wider range of responses to verbal stimuli than non-verbal stimuli depicting the same item. Corroborating this finding Bourisseau, Davis, and Yamamoto (1965) reported that word and word-picture combinations were more effective than pictures alone.

Does the complexity of a visual object determine the extent of perception? What part does the mental "set" held by the viewer play in determining what he sees? Travers (1964) suggested that complex stimuli, which flooded the learner with excessive information, were difficult to process and store. Broadbent (1958) suggested that a degree of selectivity must be established for each level of educational experience. Attneave's research (1955, 1956, 1957) would support this plea for simplicity since his conclusions indicated that boundaries of objects present more useful information to the learner than do all other parts. "Interest" on the part of a learner viewing pictorial programed material may be a direct function of the individual's ability to receive and store stimuli.

A more complex area for measurement was the cultural and personality perceptual sets of each individual. The impact of culture on learning ability was clearly stated by Hall (1959) and numerous others. Dember (1964) suggested that the effective complexity of a stimulus cannot be evaluated independently of the "complexity" of the individual. Numerous attempts have been made to develop measures designed to assess non-verbal (figural and symbolic) stimuli primarily devoid of verbal content. Guilford and Merrifield (1960), Guilford, Merrifield, and Cox (1961), Torrance (1963), Thurstone (1947), French (1951), have all contributed to this effort.

Relating to Ethnic, Social, and Occupational Groups

It was suggested by numerous researchers that perception of stimuli, verbal and non-verbal, was conditioned by yet another factor, that of the ethnic and social background of an individual. In order to determine to what degree the variables of ethnic and social grouping actually affect learning gain, the present study devoted one facet of its research to this problem.

McCullers and Plant (1964) reviewed a number of comparisons of Negro-white intelligence test scores during the past 50 years as well as recent large-scale studies in the southeast and reported that whites averaged significantly higher than Negroes. An environmental, as contrasted to a hereditary, interpretation was set forth by these two investigators. Rationale for the variance in scores included preschool differences, family cohesion, self-concept of the student, and perceived ability to control the school environment. Specific difficulties included the lack of ability to organize the stimulus field and the inability to give non-stereotyped responses. Differences in intelligence, motivation, and personality were attributed to environmental circumstances.

Numerous studies have pointed up the differences in learning abilities in Mexican-American and Anglo-American children (Koch & Simmons, 1926; Jansen, 1961; Stablin _et al._, 1961). Ethnic stratification as related to learning abilities for the aforementioned groups as well as the Oriental-Americans was examined in Shibutani and Kwan (1965). Studies pertaining to social stratification and class differences in America were recently reviewed in depth by Hodges (1964).

Low Occupation Grouping--
Lower Social Class

Most research in this area indicated that a relationship does exist between intelligence and socioeconomic status. Eells (1953), for instance, declared that children from deprived backgrounds often received scores which inaccurately reflected their basic intelligence. Newton (1959) pointed out that parents of adequate readers were significantly higher in occupational status than parents of retarded readers. Bernstein (1960) suggested that the higher intellectual development of the middle class child was a direct function of his parents' linguistic advantage. He also indicated that parental demands for academic successes were more important in the upper and middle classes and may be reflected in the higher motivation levels of students from these families than from lower class families. Conversely, lower class children were reported as having lower academic and vocational achievement aspirations than their counterparts from middle and upper class families (McCandless, 1952; Sewel, Haller & Straus, 1957).

A general profile of abilities emerges from the research in this area that seems to indicate the lower class child has the following characteristics: (1) he is inferior in abstract conceptualization and categorization of visual stimuli (Deutsch, 1964); (2) he generally scores lower on tests of verbal concepts than children in higher social classes (Siller, 1957); (3) he is poorer in auditory discrimination, manipulation of syntactical aspects of language, and in recognition of perceptual similarities (Deutsch, 1965); (4) his range of oral vocabulary is much less than children from a higher social class.

The research relating to the disadvantaged children, who could be described as suffering negative impact of social and emotional impoverishment, showed that these children were more concrete and inflexible in their intellectual functioning than the privileged child (McCandless, 1952); that the sixth grade vocabulary of these youngsters was approximately one-half of the non-disadvantaged (Figurel, 1964), and they obtained lower IQs as measured by standardized tests (Deutsch & Brown, 1964). Pasamanick and Knobloch (1958) reported finding more psychomotor and behavioral disorders and also greater reading disabilities. These children also showed a tendency to work rapidly but randomly when speed was demanded, and it was hypothesized that this was done to get out of the discomfort of the situation (Wrightstone, 1963).

Negro children. The Negro child gazes up from the bottom levels of this socioeconomic hierarchy with the added stigma of having lower recorded intelligence than those above him. If, perchance, he is able to obtain upward mobility and secure a higher rung on the economic ladder, the differences in intelligence between the groups increase as class level increases; the absolute increase in IQ is greater for the Caucasian than for the Negro group (Deutsch & Brown, 1964). He was described as being relatively poor in visual imagery (Bean, 1942), poorer than his white peers in reading and sound discrimination (Deutsch & Brown, 1964), as producing fewer sentence types, fewer complex sentences constructions, and elaborating concepts more poorly than his white counterpart (Anastasi & D'Angelo, 1952); and generally performing lower on achievement measures (Dreger & Miller, 1960). A factor mitigating the lack of ability indicated thus far was the point made by Edmonds (1962): that differences within the Negro race itself far exceeded the differences between the races.

Two recent studies provided other insights into the potential of this group. Semler and Iscoe (1963) presented similar and dissimilar paired associates tasks represented by concrete objects and pictures. No _overall_ differences were reported between white and Negro primary school children. For the five and six year old children there were significant differences favoring the white children; however, these differences were not apparent in the older groups--the groups closest in age to those under consideration in this report. A more recent study by Iscoe and Pierce-Jones (1964) indicated that Negro children between the ages of five to nine years old were superior in ideational fluency even though the white children in the study had higher IQs. The _Unusual Uses Test_ was given to white and Negro children to obtain a measure of the children's divergent or creative thinking. Somewhat related to this study was the work of Price (1962) who found that Negro and white children responded in different patterns when administered the Rorschach measure at the age levels of 6, 10, and 14. The general pattern was that as children increased in age their responses approximated the average responses of an adult in their racial group. The least difference between Negroes and whites occurred at the level of age youngest children; differences became larger with age.

Mexican-American children. Verbal and non-verbal IQ tests have tended to classify children of Latin ancestry as considerably below the average of predominately Anglo-American normative groups on which the tests were standardized (Kidd, 1962; Keston & Jimenez, 1954; Stablin _et al._, 1961). The differences between these two groups were somewhat less if non-language tests were used (Carlson & Henderson, 1950). However, both the English and Spanish versions of the Stanford-Binet tend to cluster the average IQ of the

Mexican-American youngster around 80.9 (Coers, 1935; Cook & Arthur, 1955). A more recent study of 36 children (Holland, 1960) reported that the mean WISC (Weschler Intelligence Scale for Children) was 103, and that the scores ranged from 45 to 118.

Carlson and Henderson (1950) examined the performance of 115 Mexican-American children from the Los Angeles City Schools. They conducted a longitudinal study extending from first grade to fifth which culminated in the administration of the CTMM, a measure also used in this research. The mean Language IQ was recorded at 89.6, the Non-Language at 89.3, and the total score was 88.5. Comparable mean scores for Anglo-American students were at the 103 mark. An administration of the Davis-Eells Test of General Ability to Spanish and Anglo-American children at the second through fifth grade levels yielded similar patterns: an increase in differences between the groups as age increased (Stablin, Wiley, & Thompson, 1961).

Two studies which suggest different patterns than those demonstrated by the earlier studies were conducted by Kidd (1962) and Jensen (1961). Kidd examined the culture-fair characteristics of the Cattell-Culture Fair Intelligence tests in relation to groups of Mexican-American and Anglo-American sixth grade students of upper and lower socioeconomic status. Culture-fair items were isolated by the author and significant differences were obtained between national and socioeconomic groups. The greatest difference was between the lower class Mexican-American males and the lower class Anglo-American males.

Jensen oriented his research to the question of whether Mexican-American and Anglo-American children equated in IQ, as measured by the CTMM, were also equal in learning ability, as measured by certain standard learning tasks. The learning tasks Jensen selected included immediate recall, serial learning, and a combination of a recall and paired associates task. Familiar and abstract materials were used for performing the tasks. The Mexican-American children with low IQs performed significantly better than Anglo-American children with low IQs. Dull Mexican-Americans performed as well as bright Anglo-Americans and Mexican-Americans. The CTMM seemed to have been successful in discriminating between children of high and low IQ in the Anglo-American group, but did not do so with the Mexican-American group.

Attitudes toward education among students in grades 7-12 in these two groups was measured by Demos (1962). He reported more favorable attitudes toward education were found among Anglo-Americans than Mexican-Americans when matched for age, sex, grade, social class, and intelligence.

The Oriental-American student. Recent research into the relationship of intelligence, abilities, and performance of American children of Oriental ancestry has been sparse. California, the state which still retains over one-half of the total population of Asian heritage in the United States, figured prominently in a thorough exploration of the aptitudes and status of the Oriental population. This major 1933-35 study was launched at the then Leland Stanford Junior University, and resulted in three research monographs by Edward K. Strong, Jr., and Reginald Bell (1935), dealing with the second generation Japanese in the United States. This work surveyed the existing research concerning the Oriental-American population, many studies of which included Chinese students.

One study reported that, qualitatively, the Japanese student seemed to be definitely inferior in tests involving memory and abstract thinking based on concepts represented in English words, an inferiority possibly not due solely to language handicap. On mental tests, however, that were not chiefly of verbal character, there was a "definite superiority" of Japanese and "possibly of Chinese" in comparison with Caucasians. This was particularly true of acuity of visual perception, recall, and tenacity of attention. The tests involved in the determination of these conclusions included the Stanford-Binet, the Army Beta and the Stanford Achievement Tests of 700 California-born Oriental children from 10 to 15 years of age.

Educational achievement, as measured by achievement test scores, teachers' ratings, and age-grade distribution in 1922, showed, but for one exception, educational retardation, especially on tests involving linguistic ability. In arithmetic and spelling the Oriental student seemed to be superior to whites. In another measure involving total educational attainments of the Oriental and Caucasian groups, the comparison was favorable to the Japanese-American children when they were grouped with whites whose parents were of a similar economic and vocational status. Dumas (1945) reported the results of an extensive testing program of Japanese children from grades 1 to 12 who were placed in war relocation camps during the years 1942-1945 at the Amache, Colorado Secondary School. Eighth grade students recorded median IQs equal to, or exceeding, students in this study.

The most contemporary available research pertaining to the Japanese child was undertaken by Kitano (1962). His attempt was to determine if any change in achievement patterns had occurred in the Sansei (third generation) population when compared to the Nisei (second generation) high school student. The average IQ score of the six groups sampled between 1941 and 1952 ranged from 101.7 to 110.2, with an average standard deviation of 11.4 points. The striking change was the decline in A grades from 33 to 9 percent of the population between 1941 and 1955, and the increase of C grades from 8 to 30 percent. Kitano compared his findings with Reginald Bell's, mentioned above, and concluded that the longer the Japanese group resided in the United States the less it was oriented toward achievement.

Sex

Overall IQ scores showed consistent but negligible average higher scores in favor of males, but substantial differences existed with respect to more specific abilities that made up the total score (Berelson & Steiner, 1964). In general, girls made a much higher score on the language portions including vocabulary, verbal fluency, and straight memory. Boys, on the other hand, made higher scores on the sections dealing with arithmetic or mathematics, mathematical reasoning, judgment and manipulation of spatial relationships, and mechanical aptitude. This pattern seemed to continue to be evident even on the Scholastic Aptitude Test of the College Entrance Examination (Brown, 1965). In general, achievement rankings at the elementary and early junior high school level showed that girls tended to surpass boys of the same age (Fifer, 1952). Brown and Beyou (1957) in an extensive review of research pertaining to sex as a variable in intelligence test performance argued that sex differences were present in the currently used scales and that intellectual abilities were not equally distributed between the sexes. Although ahead of girls in scientific information, but not always superior in scientific attitude at the elementary school level, boys were clearly in advance on most aspects of science by high school (Brown, 1954). Bruner and Olver (1963) reported that grouping strategies of sixth grade boys and girls were at about the same level, whereas at early grade levels girls had ranked higher in performance of this type of task.

CHAPTER III

PROCEDURES OF THE STUDY

Experimental Design and Method

Experimental Design

Three parallel experiments were conducted, each involving subject matter content possessing different inherent characteristics, either with concrete referents, with non-concrete referents, or depicting action processes. Programed learning sequences were prepared for each of the three content areas, combining three visual presentation modes (printed-verbal, still-graphic, and motion-picture) with three audio implementation modes (silent, redundant sound, and directive sound) and two programing approaches (linear, and branching). Each of the three experiments utilized a 3 x 3 x 2 factorial design wherein variables were studied in all possible combinations. The distribution of the variables studied is shown in Figure 1.

In all, 54 separate experimental programed treatments were designed, produced, and administered to the experimental subjects. This total was made up of 18 treatments for each of the three experiments. The subject matter consisted of programed sequences on various facets of the study of Crystallography, a general science topic comprehensible to junior high school subjects but not a part of the junior high school curriculum. Subjects were 1232 eighth grade students from four Los Angeles Unified School District junior high schools. Randomly selected groups of subjects were exposed to the experimental treatments individually by means of specially engineered teaching machines. Each treatment's effects were measured by means of a performance post-test given immediately

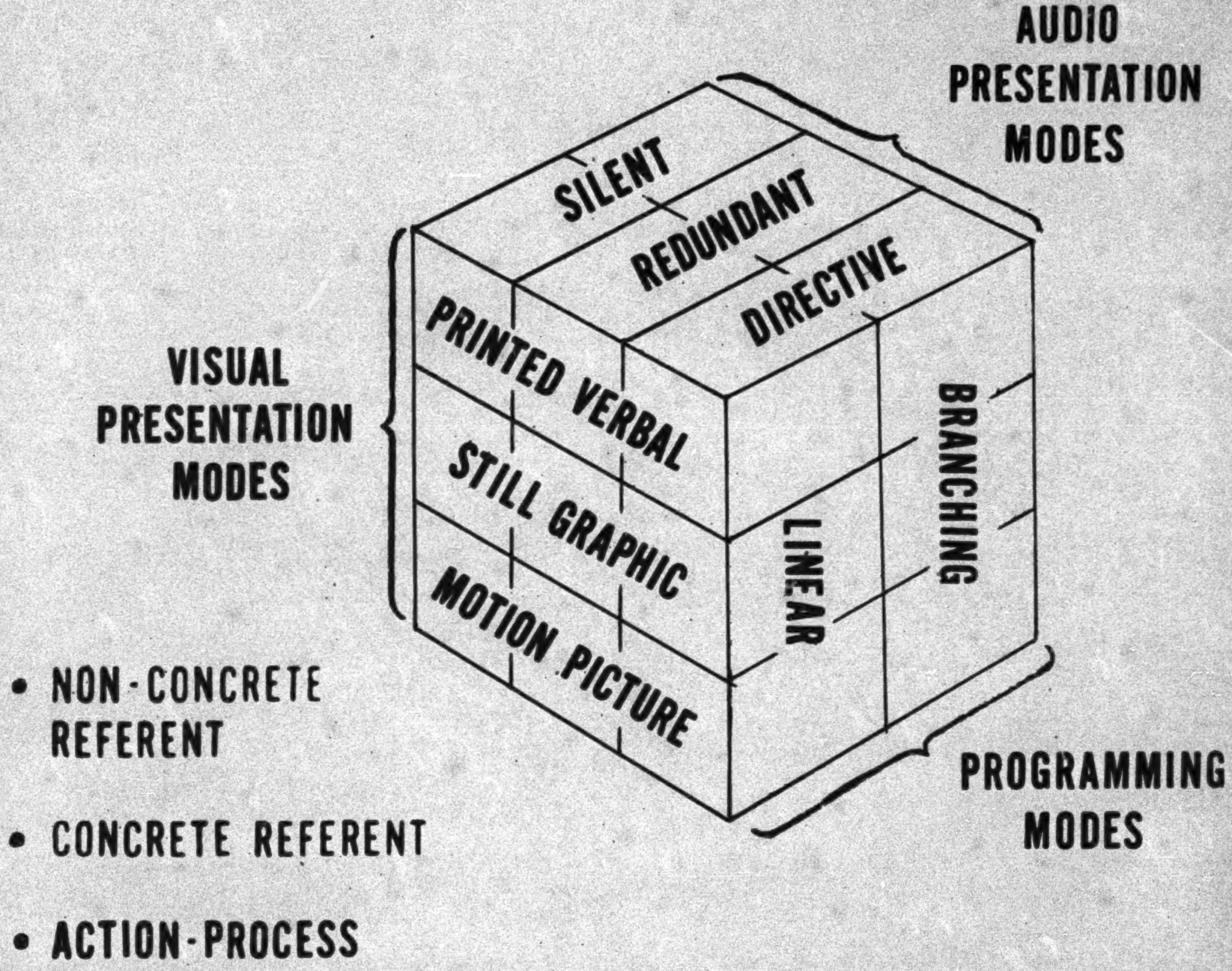
AUDIO PRESENTATION MODES
SILENT
REDUNDANT
DIRECTIVE
VISUAL PRESENTATION MODES
PRINTED VERBAL
STILL GRAPHIC
MOTION PICTURE
LINEAR
BRANCHING
PROGRAMMING MODES
• NON-CONCRETE REFERENT
• CONCRETE REFERENT
• ACTION-PROCESS

Figure 1. Model of Experimental Design

following exposure to the stimulus material and incorporating printed, verbal, pictorial, and motion picture test items. Data were analyzed separately for each experiment using a variety of statistical techniques.

Experimental Variables

Visual presentation variables. The following three different visual modes of designing and presenting the experimental stimulus materials were used (see Appendix A for examples):

1. Printed-Verbal, in which the program material was prepared as verbal frames using printed words, sentences, and figures only. This mode was similar to the usual mode of presentation of programed instructional materials. No pictorial illustrations were used.

2. Still-Graphic, in which live still photography, diagrams, realistic art work, and line drawings were added to or substituted for the printed-verbal material described above. These still-graphic illustrations were added wherever they appeared appropriate or feasible in the program, the intent being to supplement pictorially as much of the verbal program as possible.

3. Motion-Picture, in which motion picture sequences of live photography and animated diagrams, realistic art work, and line drawings were added to or substituted for the printed-verbal material described above. The motion picture illustrations were added wherever they appeared appropriate or feasible in the program and were identical to the still-graphics used except that the stills were set in motion. The printed-verbal content was not superimposed upon the motion pictures but was presented prior to or following the motion sequences.

Thus, the three visual presentation modes were designed to determine whether or not the instructional effectiveness of printed-verbal programed materials could be increased by adding or substituting still or motion pictorial and graphic illustrations.

Audio implementation variables. The following three audio modes were used for implementation of the visual presentations (see Appendix A for examples):

1. Silent, in which the program was presented by visual means alone without audio accompaniment.

2. Redundant Sound, in which the printed-verbal symbols on the viewing screen were spoken aloud word-for-word as they appeared.

3. Directive Sound, in which relevant visual cues appearing on the viewing screen were pointed out in the audio accompaniment, in this way directing attention to specific material to be learned.

Thus, the three audio modes of presentation were designed to determine whether or not the instructional effectiveness of visual presentations could be increased by the addition of different kinds of audio accompaniment.

Programing variables. The following two programing approaches were used in combination with the various visual and audio presentation modes (see Appendix A for examples):

1. Linear Approach, in which the content was presented in a preestablished sequence, requiring the subject to make an overt or covert constructed response or make an answer choice to multiple-choice questions, after which the correct answer was presented and the program continued.

2. Branching Approach, in which the answer the subject made at the various multiple-choice answer points of the main line linear program determined whether he would be presented with a remedial sequence or continue with the linear program. Therefore, the branching that occurred consisted only of remedial sequences as required by the subject's response. In every case, the correct

answer was fed back to the subject, as in the linear approach.

Thus, the two programing approaches were used in order to determine whether or not a relationship existed, so far as the programed instruction was concerned, between the programing approach employed and the visual or audio modes of presentation.

Content inherency factors. The three experiments were separately designed to include subject matter that could be characterized as possessing as inherent dominant traits one or the other of the following types of content (see Appendix A for examples):

1. Non-Concrete Referent. This content consisted predominantly of verbal concepts for which there were no direct "concrete" referents. These included the identification and definition of words, the spelling of words, and the learning of abstract concepts.

2. Concrete Referent. This content consisted predominantly of material having referents of a "concrete" nature, such as crystal shapes and forms, that were describable and picturable by means of pictorial and graphic surrogates.

3. Action-Process. This content emphasized continuous, self-contained action sequences wherein the action comprised a complete act in itself rather than a series of connected but separate actions. These included such actions as the process of "spontaneous nucleation" and "crystal growth."

Thus, the subject matter content for each of the experiments was designed to maximize the occurrence of any one of these content inherency factors, the various visual, audio, and programing presentation modes being used in combination with each type of inherency.

Experimental Population

Selection of the Experimental Population

The total experimental population consisted of 1232 eighth grade students drawn from four junior high schools in the Los Angeles Unified School District, which covers 710.6 square miles, includes slightly less than 3 million people, and has an eighth grade junior high school population of approximately 42,000 students. A distinct advantage in determining comparable variables in background was the similar administrative procedures, standardized student records, and uniform curriculum requirements present in this system's schools.

It was recognized that no one section of Metropolitan Los Angeles could be considered typical. Yet it was believed that by selecting one school in each of four geographical sections of the city, elements of a wide range of occupational and ethnic groups present in the area's population could be attained. The schools themselves were carefully chosen to include students who, on standardized intelligence and achievement measures, recorded scores in the entire range of abilities. Students in the Los Angeles Unified School District were required to complete the California Test of Mental Maturity for measuring IQ and California Achievement Tests for measuring their reading, arithmetic, English, and spelling levels. Consequently, the participating students in all four schools had both intelligence and achievement test scores obtained at the same time and administered in a uniform manner.

It was also important to find a close approximation of science curriculums in all subject schools. This criterion was fulfilled in the Los Angeles system, thereby making it possible to closely estimate prior knowledge and content being taught during the experiment in the field of general science, which was the broad content area selected for presentation in the stimulus materials.

Characteristics of the Experimental Population

Students were selected from within each eighth grade of each experimental school primarily on the basis of their class attendance. Since they were to be randomly assigned to the experimental treatments, no other selection procedures were employed. A total of 1232 eighth grade students comprised the experimental population for all three experiments. Of this number 388 participated in Experiment I (Non-Concrete Referent), 411 in Experiment II (Concrete Referent), and 433 in Experiment III (Action-Process). Of the total, 639 were girls (51.87%) and 493 were boys (48.13%). The populations in the four participating junior high schools are described below.

Junior High School A. The student population for this school was drawn primarily from middle and upper socioeconomic families. The majority of the fathers were professional men or managers of commercial businesses and the students represented primarily one ethnic group (Caucasian). On measures of intelligence and achievement the children ranked in the upper third of all students in the city school system. The classroom buildings were arranged on a well-landscaped and attractive campus. Junior High School A's students were involved in the first and second experiments. Students who were eighth graders the year before the experiments were conducted also served as members of the developmental population, as described below. A total of 299 students participated in Experiments I and II, having a mean IQ of 106.95.

Junior High School B. This junior high school was located in an economically depressed section of Los Angeles. The main school building was a two-story structure with bungalow buildings in the rear. One indication of the general socioeconomic level of the district was the fact that the parents of the majority of students were engaged in semiskilled or unskilled occupations. In numerous cases students came from broken homes or the parents were unemployed and receiving welfare aid. The students were primarily of one ethnic group (Negro) with standardized test scores at the 75th percentile or below, compared with the other students in the school system. The school services a district with a large transient population consisting of newly-arrived families from southern states and other large cities, who settled in this area first, and later moved to other sections of the city. A total of 269 students participated in Experiments I and II, having a mean IQ of 92.92.

Junior High School C.—This school was located in an area that still retained some aspects of its recent agricultural past, such as small working dairy farms. The school buildings were arranged on an attractively landscaped and spacious campus. The students came from homes representing many occupational backgrounds but the majority of families fell into the middle and lower-middle income groups. The majority of the student body came from three ethnic groups (Caucasian, Negro, and Mexican-American). The students in the school recorded test scores on standardized measures that would place them approximately in the upper two-thirds of all the students in the school system. A total of 342 students participated in Experiments II and III, having a mean IQ of 104.81.

Junior High School D.—This school was situated in a highly urbanized section of the city. Many parents of these students were employed as retail clerks or as service personnel in local restaurants, in television, or in the movie industry. The main school building was two stories high, of Spanish architecture, with bungalows adjacent to the central building. The students primarily represented three ethnic groups (Caucasian, Mexican-American, and Oriental), and recorded scores on standardized measures covering the entire range of student abilities. A total of 322 students participated in Experiment III, having a mean IQ of 103.77.

Distribution of the Population to Experimental Treatments

The method used for assigning students to the experimental treatments involved the use of a table of random numbers as described by Walker and Lev (1953). Following the assignment of a unique number to each student, these numbers were then assigned randomly to 18 groups for each experiment. If the student population from one school was to be divided and assigned to two experiments the same procedure was followed; however, when the total number desired for one experiment was obtained, the other numbers were then assigned randomly to the 18 groups in the second experiment. A pool of 36 students was provided, for each experiment, to provide substitutes for absentees.

In the foregoing fashion students from Junior High Schools A and B were assigned randomly to Experiments I (Non-Concrete Referent) and II (Concrete Referent), the students from School C to Experiments II and III (Action-Process), and those from School D to Experiment III.

Characteristics of the Experimental Treatment Groups

The subjects for each experiment, and for each school within each experiment, were assigned by means of a table of random numbers to each of the 18 experimental treatment groups. Analyses of variance were performed to determine if the distribution of subjects to the 18 treatments, based on total IQ score, had been random. The analyses compared the variation between and within the groups receiving each experimental treatment. The mean scores and standard deviations for total IQ score are presented in Table 1, and the results of Bartlett's test for homogeneity of variance are presented in Table 2. The F values for the Bartlett's test were not significant for any of the three experiments, confirming the validity of the randomization procedure and attesting to the comparability (in IQ) of the treatment groups in each of the experiments.

Program Development Population

Four separate groups of students were involved as test subjects in the development of the programed materials. Junior High School A provided eighth graders who helped with the development of the Non-Concrete Referent materials a year before the experimental data were collected. Students who had completed the first half of the eighth grade, and would not be eligible as subjects for the experiments, assited with the development of the Concrete Referent, and Action-Process programs.

The Culver City Junior High School, external to the Los Angeles Unified School District, provided six eighth grade students, during the summer session of 1963, to act as subjects for program development of the Non-Concrete Referent materials. These students were in summer school for remedial

TABLE 1

MEAN SCORES AND STANDARD DEVIATIONS FOR TOTAL IQ SCORES BY TREATMENTS WITHIN EACH EXPERIMENT

	Experiment I			Experiment II			Experiment III		
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ
Print/Silent/Linear	26	100.30	13.07	25	100.44	13.35	24	106.75	13.98
Print/Silent/Branching	21	96.71	15.29	20	108.65	10.70	24	107.50	14.64
Print/Redundant/Linear	20	98.10	11.89	25	100.32	14.17	26	100.42	14.13
Print/Redundant/Branching	20	102.50	15.28	20	102.70	12.58	26	102.57	14.93
Print/Directive/Linear	24	102.08	13.77	23	103.86	14.72	25	104.50	14.75
Print/Directive/Branching	22	103.36	12.78	23	105.60	15.81	26	106.69	14.93
Graphic/Silent/Linear	22	102.59	14.84	24	103.75	10.90	25	100.44	11.46
Graphic/Silent/Branching	20	96.85	15.21	21	102.95	16.39	25	100.40	14.18
Graphic/Redundant/Linear	19	100.42	9.62	24	102.45	16.06	25	96.20	11.93
Graphic/Redundant/Branching	21	94.71	13.73	23	100.00	17.30	21	103.71	12.04
Graphic/Directive/Linear	21	102.80	12.35	22	105.13	12.25	22	104.13	20.47
Graphic/Directive/Branching	20	100.25	13.50	24	99.70	12.60	21	107.33	15.02
Motion/Silent/Linear	23	102.78	15.49	24	105.33	12.31	23	105.04	10.66
Motion/Silent/Branching	19	98.61	12.17	24	104.87	16.04	24	105.12	16.45
Motion/Redundant/Linear	23	102.04	13.69	25	105.60	15.07	25	102.08	12.54
Motion/Redundant/Branching	22	99.77	11.17	24	101.45	13.48	24	103.58	15.22
Motion/Directive/Linear	23	101.82	14.34	22	103.13	13.23	26	105.73	14.67
Motion/Directive/Branching	22	100.22	14.06	18	104.22	14.54	21	103.28	15.55
Total	388	100.34	13.48	411	103.27	14.01	433	103.58	14.44

TABLE 2

HOMOGENEITY OF TOTAL IQ MEANS FOR THE 18 TREATMENT GROUPS (ANALYSIS OF VARIANCE)

	Source	df	SS	MS	F	Correlation Ratio	p
Experiment I	Between	17	2150.53	126.50	.685	.174	---
	Within	370	68241.34	184.43			
	Total	387	70392.03				
Experiment II	Between	17	2182.81	128.40	.644	.164	---
	Within	393	78325.02	199.30			
	Total	410	80508.00				
Experiment III	Between	17	3621.75	213.04	.102	.200	---
	Within	415	86503.10	208.44			
	Total	432	90125.06				

work and provided a marked contrast in ability to the students from Junior High School A.

Fourteen students from Junior High School E in the Los Angeles Unified School District were used for establishing the reliability of the Non-Concrete Referent programed materials on the teaching machines. Nine girls and five boys participated in this phase. Their IQs ranged from 81 to 132. Twenty students from this school also served as subjects for the development of the Concrete Referent materials. The students came from predominantly lower income families of one ethnic group (Negro) and from a school which was situated in an economically depressed section of the city. This group helped to establish the wide range of student abilities used for developmental testing of the programs.

During the summer session of 1964, McKinley Junior High School in Pasadena, external to the Los Angeles Unified School District, provided approximately 80 eighth grade students. These students served as a pretest group under actual operating conditions, of the Non-Concrete Referent programs, the experimental equipment in the trailer, the performance test, and the F Battery test.

Environmental Controls

Controls were exercised over the environment of the experiment by standardizing the conditions under which the stimuli were presented and the subjects tested.

Space

The 40-foot long experimental trailer, utilized in all phases of the project, was 10 feet wide on the exterior and contained about 350 square feet of space in its interior. On the left, as one entered the trailer, a small anteroom was located. Here students waited their turns to use the teaching machines and, when finished, waited to be escorted to the performance test area. To the right of the entrance were six teaching stations. Each booth contained a screen, a five-key response panel, a small desk with an area for writing on a response sheet, and headphones. Each of these pieces of apparatus was connected to equipment on the other side of a wall that separated the booths from the equipment. The apparatus used is shown in detail in Appendix B. This narrow room, running two-thirds the length of the trailer contained the slide and motion picture projectors, tape players, control equipment, and IBM card punch. The air-conditioning unit in the trailer provided a constant and comfortable temperature in the trailer.

Light

The attempt to provide optimum testing conditions and uniformity of design extended to the lighting conditions within the trailer. The lighting used in the rear screen projection process and for performance testing purposes was within recommended tolerances for material viewed by the rear screen projection within the presence of light, as suggested by Terlouw (1956). There was a high degree of uniformity in ambient light present in the rooms used for performance post-testing. Rooms were darkened by drawing light-proof drapes or venetian blinds. The ambient light present in the trailer and the post-test rooms was not considered objectionable.

Sound

All subjects, including those who viewed the silent versions, used the headphones, which served to mask out extraneous noise when sound was not employed. The sound level was often reassessed for each headset, and adjustments were made for individual students when necessary. Controls employed to minimize ambient sound included warnings to the students being tested and students on the grounds outside the trailer and testing rooms not to talk in loud voices during the test periods.

Presentation

Controls exercised in the presentation of stimulus materials included positive matching of students' names and numbers with teaching machine treatments. This control included having students write their names on the paper roll at each station and then comparing these with assignment lists. Standardized seating, standardized projection systems including screen size, surface, and location, were applied in presenting stimulus and performance post-test materials. Controls exercised in the presentation included consistent procedures for guiding students to the post-test room from the trailer. The relationships between the seated viewers and the screen were based upon the recommendation of the Foundation for Effective Audio-Visual Projection (Eastman Kodak Company, 1957). Seats used in the trailer were comparable for all students, and chairs normally used for students at each school were utilized in performance post-test rooms. No extreme variations in local weather occurred during the experiments.

Scheduling and Testing Procedures

Students were selected to receive a summons based upon prior assignment to an experimental group. Those students assigned to the six experimental versions in operation on a given day were subject to call. Upon arrival at the experimental trailer, they were requested to wait their turns or take their places at the appropriate teaching booths. Students were then carefully matched with the correct machine and treatment, and each student received identical instructions from one of the project staff in the use of the teaching machines. After completing the stimulus materials, students waited to be conducted to the post-test room. Once there, they were given identical oral and written instructions concerning the post-tests. Administrative procedures were carefully controlled by giving printed instructions for each test to the students and by briefings and printed instructions given the administrators to guide them in conducting the testing sequences.

Development of the Experimental Stimulus Materials

Description of Stimulus Materials

The experimental visual stimulus materials were presented via black and white 2" x 2" transparency slides and on 16 mm. black and white motion picture film. The audio stimulus materials were provided by magnetic recording tape or via the sound track on the motion picture films. Motion versions were projected by use of Bell and Howell Model 542 sound motion picture projectors. Non-motion (printed-verbal and still-graphic) versions were projected on Kodak Carousel slide projectors with sound stimuli transmitted by Cousino Model R-7320 Repeater Tape units.

Each of the three experiments (Non-Concrete, Concrete, and Action-Process) had stimulus materials prepared in 18 different versions in accordance with the 3 x 3 x 2 factorial design. The printed-verbal, still-graphic, and motion picture visual presentation modes were combined with silent, redundant, or directive sound audio presentation modes and were presented in either linear or branching sequences. Eighteen combinations of stimulus materials were produced by combining the various modes. Repeating the experiments with the three different types of content increased the number of distinct stimulus materials to a total of 54. Excerpts from the visual and audio presentations illustrating the characteristics of the different treatment modes are given in Appendix A.

The stimulus materials were presented to the students via rear screen projection. One slide was presented at a time, with matching audio accompaniment. In the motion versions, visual stimuli, comparable to the content on one slide, were presented with identical audio content. The subject determined when he would view and hear the next group of stimuli in the teaching program by advancing the teaching machine. Visual and audio stimuli were identical except for the minor variations of the particular treatment. A combination of verbal and graphic stimuli comprised the still-graphic mode, whereas the verbal stimuli appeared alone in the printed-verbal mode. In the motion picture mode, verbal and graphic stimuli were put "in motion" by use of live action or animation techniques. Photographs and animation frames used in the still-graphic treatments were taken from the motion-picture sequences.

Audio stimuli in redundant, directive, and silent modes remained constant regardless of the manner of visual presentation. The stimuli, both visual and audio, in the linear and branching programs were identical in every way except for the added stimuli provided in the branching sequences.

The stimuli were produced in black and white instead of color in order to control for the possible differential influence of color, thus eliminating this variable as a factor in the study.

The motion picture films of Experiments I and II relied, almost completely, on animation sequences as contrasted to live photography. The film footage presented in Experiment III did not utilize dissolves, superimpositions, or fades when combining verbal and visual stimuli. In Experiment III verbal material appeared on the screen followed either by animated sequences or by a motion sequence utilizing film footage produced prior to the experiment and adapted for this study. The transfer process, whereby individual frames from the motion footage were transformed into slides for use in the graphic versions, sometimes resulted in reduced clarity of these photographs used as stimuli in the still-graphic treatments. The age of the film and processes available for transferring frames from film footage to 2" x 2" slides were both major factors affecting the clarity of this still-graphic visual stimulus.

Selection of Content and Teaching Objectives

Content. The topics had to be unique in order to minimize the number of eighth grade students with prior knowledge of the content; yet the content would have to be suitable for learning by this student population. A paramount criterion was the requirement of breadth and depth in the content area selected. The subject designated had to be rich in range of topics, and these had to be readily identifiable as the same order of tasks taught in other subject areas. A further requirement dictated that the content selected lend itself to structuring a theoretical framework which could be generalizable to all content areas. The range of topics had to be compatible to the format being used for presentation and compatible with the variations in the treatments proposed. Finally, it had to be capable of economical expression in the media being employed in the study.

Teaching objectives. The selection of teaching objectives for the three experiments was related to the factors of content inherency identified as Non-Concrete, Concrete, and Action-Process. In many programed instruction studies results were reported that dealt specifically with the program's subject matter, such as spelling, mathematics, or chemistry results while using programed materials. In order that the conclusions from this particular study would not be related to the subject matter per se, an attempt was made to select three content areas within the overall subject of crystallography that also appeared in other subject disciplines.

The first content area programed for experimental purposes dealt with Non-Concrete Referent materials. The terminal behaviors included the identification, definition, and spelling of words; ordering of combinations of verbal symbols from the smallest to the largest; and recognition of orderly and disorderly conditions such as those characterized by the words "crystalline" and "amorphous." The teaching objectives for the Non-Concrete Referent programs included tasks in which the subject dealt mainly with the manipulation of verbal symbols that did not have any specific "concrete" referents. The objectives indicated that upon completion of the program the student would be able to:

1. Spell and define the words: crystal, crystalline, crystallography, and amorphous.

2. Discriminate the correct spelling of each of the above when presented along with incorrect spellings of the same word.

3. Write a definition of the science of crystallography by distinguishing between key aspects of this science; namely the structure, systems, and properties of crystals.

4. Rank the following from the smallest to the largest and identify the relationships between each: atoms, structure, system, and crystallography.

5. List five physical properties of crystals.

The second experiment, Concrete Referent, dealt with content normally presented by using photographs or drawings. Students were taught to identify and to compare and contrast crystals with reference to the properties of color, shape, and surface texture. Upon completion of this second instructional program students were expected to:

1. Recognize and distinguish between drawings and photographs of crystals of galena, pyrite, halite, calcite, quartz, and beryl by using the properties of color, shape, and texture.

2. Spell the names of the six crystals.

3. Recognize and write a definition of a crystal cluster.

4. List three types of crystal surfaces.

5. Compare and contrast faces, edges, and corners of a crystal by identifying their position and then selecting statements describing the characteristics of each.

6. Identify color photographs and drawings of all six crystals without prior exposure to color representations of the crystals.

7. Differentiate between color renderings of the six crystals studied when presented with color renderings of crystals not taught in the program.

The content programed for the third experiment, Action-Process, required the student to identify the central relationship that linked all the parts of a process and directly or indirectly caused the final result. Critical points in the process had to be recognized and related to all the other facets of the process. Opportunities to perform problem-solving tasks were built into the Action-Process sequences. The teaching objectives for this experiment required that the student be able to:

1. Compare and contrast the characteristics of a saturated and super-saturated solution.

2. Specify the processes required for preparing both types of solutions.

3. Write a definition of a saturated solution.

4. List three variables vital for crystal growth.

5. Identify by selecting from a list the correct sequence of processes required for growing a crystal.

6. Identify the correct definition of cleavage, specify how it occurs, and state how it is related to crystal growth.

7. Spell and define "spontaneous nucleation."

8. Solve a problem involving spontaneous nucleation and recognize the variables that may cause it to occur.

9. Differentiate the action of molecules in a saturated and super-saturated solution, during crystal growth, and during spontaneous nucleation.

10. Contrast the temperature and molecular relationships during crystal growth and when spontaneous nucleation occurs.

Entering behaviors. The following steps were taken to assess the level of prior knowledge of the subject matter and entering behaviors of the student population selected for the experiments.

1. An analysis was performed of Los Angeles Unified School District science syllabi, recommended for grade levels 5 to 9, to ensure that the subject matter selected was unique.

2. Interviews were held with the science faculty members at each junior high school involved in the developmental and experimental phases of the study to be certain that the content did not duplicate any prior instruction or teaching in process. Any content that approximated subject matter "in-use" was eliminated from the list of teaching objectives.

3. Pretests were given to students involved in the developmental testing of the programs to determine prior knowledge of the content being programed.

4. Once the experimental trailer was on location at a junior high school, a final review was held with

science faculty members prior to beginning an experiment. Examinations of content outlines scheduled for science classes during the experiment period were conducted. Students who were known to have individual science projects in process in any way related to the experimental content were eliminated as subjects. Science faculty members agreed not to discuss any questions pertaining to the content raised by students who had participated in the experiment until all scheduled students had completed the experimental phase.

The assumptions as to entering behaviors, based upon the foregoing procedures, indicated that the subjects had:

1. A knowledge of the general appearance of a crystal.

2. No prior knowledge of the crystallography content covered in the three experiments.

3. Completed the science course of study recommended into the eighth grade level.

4. A sixth grade reading ability level as indicated by both CTMM and CAT scores obtained in October, 1965.

Construction of the Programs and Developmental Testing

Linear. The linear program provided the foundation for both programing modes utilized in this research project. The teaching objectives designated for each experiment were first translated into teaching points for the linear program sequences. These teaching points specified the content and behavior required to meet each objective and were critiqued to insure content accuracy and integrity by members of the research staff, university content specialists, science curriculum personnel from the Los Angeles Unified School District, and classroom science teachers.

In order to provide a format amenable to easy editing and to presentation of individual frames, each item was written on a 3-1/2" x 7-1/2" card, such as the IBM 5081 card normally used for data processing. Stimulus material was placed on one side of the card and the correct response on the opposite side. All programs were edited by project staff members prior to their first use. Initial program revisions were made on the basis of these critiques.

The students, identified earlier in this report as the "developmental population," were utilized in the field testing of the trial programs. Each small group of students participated in the developmental phase during their regular science periods or immediately following the last school period in the day. At that time the students were first instructed in the correct procedures for using programed materials. Then each student viewed the stimuli on the cards, made overt written responses to each item, and turned the card over for confirmation of his response. Students were encouraged to raise questions and criticize any stimulus frame or response that was unclear, incorrectly sequenced, or overly difficult. If the student did suggest revisions for such frames, his ideas were carefully considered in designing the change. In the case of the Action-Process program, cards and appropriate motion picture sequences were used together and the projector was stopped following each short film sequence to obtain student feedback.

Student attitudes toward the instruction method and the content itself were obtained orally. A post-test was then administered to assess attainment of the desired teaching objectives. Prior to involving a second student, a data summary sheet for each frame and sequence in the program was analyzed and iterations were made. Flexibility obtained by use of the cards provided for rapid resequencing of items "on-the-spot." In this fashion five or six students were put through the program's first trial run. The objective was to select these students to represent a range in ability levels from lowest to highest and for their articulateness, as determined by both the project member and the classroom teacher.

After collecting the information for this phase, the data summary and field test notes were analyzed and program revisions accomplished. Each frame and sequence was examined for the error rate ratio. To insure that factors other than the programing variable would not account for a high error rate, efforts were made to have all programs teach at a ninety percent errorless rate, ninety percent of the time. When this level of performance could not be obtained in a given sequence it was subjected to a revision. At the same time, a determination was made as to whether a branching sequence could be introduced effectively.

Branching. Procedures similar to the linear techniques were employed to construct the branching sequences. The positioning of the branching options was accomplished primarily in three ways.

1. If error rates remained high, following revisions, for average and below average students on a particular subcriterion frame or sequence of frames, a multiple-choice stimulus frame was inserted at the critical juncture in a sequence. Then the selection of an incorrect option in the frame would transfer the student to a branching sequence that provided additional practice of the desired response, or retaught the content using an entirely different approach. In most cases where the EGRUL strategy (providing examples, followed by exposition of the rule) had been utilized in the sequence leading up to a multiple-choice frame, a RULEG (statement of the rule followed by illustrative examples) approach would be used in the branching sequence.

2. A branching sequence might be established where a linear frame with a two or three choice formal prompt already existed.

3. If the programer felt, based on his creative and intuitive assessment that the structure of the content required a discrimination between certain words, ideas, or concepts, a branching sequence was framed.

Validation Field Testing

Validation field testing commenced once the final configuration of both the linear and branching sequences was established. Eighth grade students at the same junior high school, who were not members of the developmental or experimental populations, completed the programs in groups of four or five. Approximately fifteen students participated in this phase of the field testing for each experiment. Every attempt was made to secure students at each ability quartile that would be included in the experimental population. During this phase patterns of responses to the stimuli material, time to complete the programs, and student acceptance of the content and format were recorded and analyzed.

The foregoing procedures were repeated for each experiment when developing stimulus materials. The three experiments--Non-Concrete, Concrete, and Action-Process--each required the construction of two separate trial programs and separate field testing activities. For instance, in the case of the Non-Concrete Referent experiment a program was written using only verbal symbols; thus utilizing the one stimulus that lends itself most readily to the inherency of the Non-Concrete content. This program's primary teaching goal was to produce a manipulation of verbal symbols. Following the field testing and stabilization of the program a second program, featuring graphics, was written utilizing both graphic and verbal symbols. This program was also field tested in the manner described above.

Similar procedures were followed in Experiment II (Concrete Referent), but in this instance the initial program utilized (primarily) graphic symbols--the stimuli most closely related to the teaching objectives. This program was then translated into a verbal version. It was felt that a separate field testing cycle was not required for the motion version of the first two experiments since the motion version was obtained by putting the "still-graphics" in motion. However, in Experiment III (Action-Process) the base motion program format was field tested and then translated into a verbal and graphic program. The verbal and graphic programs were subsequently subjected to developmental and validation testing. The audio treatments, on the other hand, were developed and field tested in conjunction with the teaching machine and program compatibility tests that are described in a later section.

Production of Machine Materials

Special scripts. Upon completion of the validation testing, special production scripts were prepared for use in the experiments. Eight scripts were required for each program in order to facilitate the transfer of the content to 2" x 2" slides, magnetic tapes, and motion picture film. For example, the program using verbal stimuli required a special script for the linear treatment, the two audio treatments of redundant and directive sound, and a script for each branching sequence identified as Branch A, B, C, and D. Once the scripts were evolved, a number of meetings were held with the film production and animation specialists of the University of Southern California Department of Cinema. Guidance obtained at these conferences resulted in incorporation of information in the scripts, such as running time required for each frame in the film sequences and narration time in the audio versions. The final scripts then were typed and duplicated for use in recording the narration, preparing the final art work, setting type and editing the post-test and final versions of the film.

Slides.--The content in each script was set in 24-point futura demibold type face and printed on standard animation sheets (15-1/2" x 12-1/2") for each frame. Where art work was required in the script, the animator prepared the art work on comparable animation cells and coded it to match the scripts. The cells were photographed on 35 mm. Kodachrome film, using a Pentax with a 50-foot magazine. This procedure was followed for the printed-verbal and still-graphic treatments. The slides were mounted in 2" x 2" cardboard frames and placed in 80-slot Carousel projector slide trays for use by the subjects.

Motion picture films.--The film versions were produced in much the same way as the slides except that the appropriate number of exposures for each cell had to be carefully checked in order to provide the desired motion effect and appropriate viewing time. The animation photographer photographed the sheets on a nine field using a Richardson-Bowlds animation crane, Model RB-200, a 16 mm. Acme Reflex animation camera, and Ektachrome commercial color film, type 7255 (reversal). Exposed film was developed in the University of Southern California's film laboratory using standard Eastman procedures. Work prints were edited further to fit the sound tracks, and were reviewed using sound-picture interlock in order to provide a final check on the overall production sequence. In the Action-Process experiment, some action film footage was duplicated from existing films and spliced in to the negative.

Machine-Program Reliability Procedures

While stimulus materials were being prepared for use on slides, film, and tape, prototype teaching machines also were being developed. Compatibility of these materials to the machines, as determined by student use, was assessed at the Cinema Research facility.

Ten students at a time were transported from Junior High School E to the University of Southern California campus in order to use prototypes of the linear and branching teaching machines designed and constructed for the research. The first step in this reliability test was to give preliminary instructions to the students in the proper use of the teaching devices. In addition to oral directions a programed linear sequence provided instructions on the use of machine and methods for responding to the stimulus materials. Further guidance was provided by the program itself in how to advance the machine, selection of multiple-choice options, identification of portions of the stimulus frames requiring responses, placement of written responses, and emergency procedures should the machine fail to operate.

A careful examination was made, following each individual trial, of the effectiveness of the instructions and the teaching programs, the concordance between machine direction and program presentation, and student attitudes toward the total experience. Relevant revisions were made to the appropriate aspect after each student trial. A pilot run was conducted following these tryouts after the machines and majority of programs for Experiment I were completed. During this phase the experimental trailer was located at McKinley Junior High School in Pasadena. The approximately eighty summer school students who participated were representative of the eighth graders in the Pasadena School system. This pilot phase provided an excellent opportunity to evaluate the total research system. Procedures examined and revised during this phase included:

1. Methods for obtaining student data, summoning and assigning students to experimental treatments.

2. Orientation of students to the research activity.

3. Instructions for use of the equipment.

4. Behavior and performance of students during the instructional period.

5. Administration of F Battery and performance post-test measures as well as student performance on both.

6. Integration of experimental requirements with the on-going school program.

7. Technical considerations of machine, trailer, and school compatibility.

Instrumentation

Details of the teaching machines developed for these experiments have been described in print by their designer, Donald G. Perrin (1964). An offprint of this paper is included in Appendix B. The discussion to follow provides a brief summary of that description and adds additional details pertinent to the operation of the machines.

Design

The requirements of the present study called for rapid branching among motion picture sequences and among still-frame sequences accompanied by sound. Originally, the plan was to use a commercially manufactured teaching machine; but this equipment was incapable of meeting the branching requirement, and it became necessary to design a completely new display system. This system combined off-the-shelf components with newly designed electronic control and switching units. In addition, a monitoring and control panel was designed to link all machines to a card punch, manufactured by International Business Machines, for the purpose of recording each item selection and branch taken by each subject for the entire duration of his machine experience.

The Teaching Machine Display System

The complete display system used in the study consisted of six separate teaching machines, as follows (illustrated in Appendix B):

1. One motion-picture branching machine consisting of the four modified Bell and Howell sound motion picture projectors.

2. Two still slide branching machines consisting of the eight (four for each machine) modified Eastman Carousel slide projectors and the eight (four for each machine) Cousino Repeater Tape units coded to activate the slides.

3. One motion picture linear machine consisting of a single modified Bell and Howell sound motion picture projector.

4. Two still slide linear machines consisting of two (one for each machine) modified Eastman Carousel slide projectors and two (one for each machine) Cousino Repeater Tape units coded to activate the slides.

The subjects sat in six partitioned booths separated from the machines by a plywood panel. Subjects viewed a rear projection screen, used a five-key (ADVANCE and A, B, C, D,) response panel to advance the program to select branching choices, wrote on a roll of adding machine tape which advanced automatically as the program advanced, and wore headphones for the reception of the sound or the elimination of extraneous noise.

A monitoring and control panel linked all machines to an IBM 523 card punch, which recorded each response made by each subject. Also, a record was kept on the punched cards of the time taken between each selection and of the total time on the machine.

The Measuring Instruments

Performance Tests

Three performance post-tests (see Appendix C) were developed, one for each of the three experiments. The first draft of each test was designed to measure the terminal behaviors identified earlier. Each test employed multiple-choice, fill-in, and short answer items. Some items in each test involved graphic materials, and some items in each test were presented by motion picture film projected on a screen. In Experiment II, 12 items employed slides as stimulus material.

Item types written for the tests in the three experiments attempted to incorporate tasks defined by the five major categories in Bloom's Taxonomy: Knowledge of Specifics, Comprehension, Application, Analysis, Synthesis, and Evaluation (Bloom, 1956).

In each instance where the teaching of particular behaviors was attempted in the teaching materials, special items or presentation formats were developed to assess transfer ability. An example of this approach would be the case of discrimination tasks presented by test items that used photographs, as contrasted to line drawings, projected onto a screen.

Table 3 shows the distribution of item types for each experiment. The distributions vary because of the differences in content presented in the training materials.

The different item types are defined as follows:

Completion spelling.--Sentence completion item scored for correct spelling of words specified in the teaching objectives.

Verbal fill-in and multiple-choice.--Sentence completion or multiple-choice items with purely verbal stems.

Graphic fill-in and multiple-choice.--Sentence completion or multiple-choice items with graphic materials as important part of stem.

Open end.--Short answer items with sentence construction required. Component words or correct state of ideas were recorded.

Film presentation. Multiple-choice items with a major portion of the stem containing graphic material was projected on a screen.

Slide presentation. Line drawings or color photographs were projected on a screen. Graphic material presented required a recognition or discrimination task or selection of multiple-choice options.

TABLE 3

DISTRIBUTION OF ITEM TYPES FOR EACH EXPERIMENT

Item Type	Experiment I	Experiment II	Experiment III
Fill-in Items			
Completion spelling	4	--	--
Verbal fill-in and multiple-choice	17	8	17
Graphic fill-in and multiple-choice	5	16	8
Open End			
Short answer	5	9	2
Sequence	--	--	1
Things to make	--	--	1
Film presentation (multiple choice)	4	4	8
Slide Presentation			
Naming (fill-in)	--	6	--
Matching (multiple-choice)	--	6	--

Each test was tried out on students during the developmental phase of the study simultaneously with the development and revision of the experimental program treatments. Item analysis techniques were used to delete some test items, to revise others, to eliminate extremes in difficulty, and to increase the probability of higher correlations between item score and total test score.

The test questions were provided in a booklet organized in a checkbook format to deter students from looking ahead or back at items.

F Battery

The tests comprising the F Battery were assembled to measure certain capabilities of students, which, when evaluated with available IQ and achievement scores, might improve predictions of performance with audio and visual programed materials. A separate post-test taken by eighth grade students following instruction via an audiovisual teaching machine was used to assess performance. The expectation was that, if the F Battery would be useful in improving predictions in this context, it could be utilized when forecasting performance with similar stimulus materials. Explorations could then follow of the relationship of student abilities, not normally assessed by intelligence measures, and how performance and these abilities were related to certain combinations of instructional stimuli.

The F Battery was constructed by selecting a number of tests identified as being factorially unique by the research staff of the Psychological Laboratory of the University of Southern California (cf. Guilford & Hoepfner, 1966). All the tests selected were based upon the "Structure of Intellect" model (Guilford, 1955, 1960). This model provided for a logical and systematic placement of every "known" intellectual ability. The tests chosen had been identified as being related to one of some 55 different intellectual abilities ascertained through the use of multiple-factor analysis by the Aptitudes Project of the Psychological Laboratory. Significant contributions in this area have also been made by Thurstone (1947) and French (1951, 1963).

Rationale for Selection of the Tests

In addition to factorial uniqueness, the tests were selected based upon: (1) prior use and reliability with a preadolescent/adolescent population, (2) dissimilarity to subtests of the IQ and achievement measures, and (3) relationships to tasks required in responding to the stimulus materials provided in the programed sequences.

Approximately 100 tests used with adolescents and related to the "Structure of Intellect" model were available. These measures had been developed with adult populations and then reliability estimates were obtained for adolescent or preadolescent populations. The reports discussing this work included Merrifield, Guilford, and Gershon (1963), Gershon, Guilford, and Merrifield (1963), Peterson, Guilford, Hoepfner, and Merrifield (1963), French (1963), and Guilford and Hoepfner (1966).

Since a major concern of the research study, for which this Battery was constructed, was to compare printed verbal and graphic stimuli, tests were selected that measured the student's ability to identify, compare and contrast, and construct graphic figures. The specific tests that were selected measured the student's ability: to judge quickly and accurately units of figural information as being identical or dissimilar, to produce many simple figures that conformed to given specifications, to produce changes in figures that altered the meaning significance or use of elements, or to classify the same items of figural information in different ways.

The tests selected to measure these abilities were:

1. Identical Forms. This involved finding the form (graphic figure) that was identical with the given form. This task of figural identification is traditionally known as "perceptual speed" and is used to identify the structure of intellect factor Figural Identification or EFU (Evaluation of Figural Units).

2. Making Objects. Given a small set of familiar geometric figures, such as a triangle, rectangle, circle, or a trapezoid, the student had to combine them in various ways to produce specified objects, such as a lamp, a clown, or a face. The factor of intellect measured by this test is DFT (Divergent Production of Figural Transformations).

3. Match Problems IV. Given a set of adjacent squares, the sides of which are said to be made of match sticks, the task is to remove an unspecified number of

matches to leave a specified number of squares, with all remaining squares complete. This test also measured DFT.

4. Figural Similarities. Given six figures of a geometric type, one must identify as many subsets of three as possible, each subset being based upon a common property. All possible combinations are listed by letter symbol and the student must indicate whether or not it constitutes a class. This test is one used to identify the factor of intellect labeled DFC (Divergent Production of Figural Classes).

In addition to the figural tasks, the stimulus material in two experiments required the student to place events in a correct sequence or order elements from the smallest to the largest. Two tests were selected that would measure these abilities. One required interaction with verbal symbols, the other with numerical symbols.

5. Sentence Order. Given three sentences describing specific events the pupil had to place them in a sensible order. The events depicted were every day occurrences that would be familiar to eighth grade students. Designed to measure the ability to order semantic content, this test aided in the identification of the factor CMS (Convergent Semantic Systems).

6. Right Order. This test provided the student with a number and three numerical operations that he could use to arrive at a second specified number. There was only one right order and he had to decide on the right order. These tasks attempted to measure the ability to convergently produce a system starting with a few symbolic units. The factor of intellect labeled NSS (Convergent Production of Symbolic Systems) is the factor measured by this test.

A seventh test was added to the Battery due to its similarity to yet another task required in the stimulus materials. This test required the student to recognize a word whose letters had been scrambled.

7. Omelet Test. The student was presented with four letters and told that they could be arranged to make a word. He had to indicate the first letter of the word. This task of symbol cognition is listed as the factor CSU (Cognition of Symbolic Units).

Developmental Testing of the Battery

Once assembled, the Battery was administered to 80 eighth grade students attending summer school at McKinley Junior High School in Pasadena, California. During this developmental phase information regarding the difficulty level of tests, the clarity of instructions, and procedures for standardizing the scoring were examined. The eighth grade students were children from a community that has lower, middle, and upper class residents, and whose parents were unskilled, sub-professional, and professional employees.

Following the administration of the Battery, modifications were made to the test instructions. Careful attention was given to modifying the directions in such a fashion as to provide clarity in identifying the task required of the student, yet not revealing the subtleties of understanding that students had to demonstrate while taking the test. Frequency distributions were examined for irregularities, and where portions of a total test were used, these were inspected in relation to reliability estimates and correlations with the parent test to insure that a comparable sample of behavior was being obtained.

All tests were scored by two individuals independently of each other. Where they disagreed on any response, assistance was obtained by the scorer-arbitrator of the research study from experienced scorers of the Psychological Laboratory.

Semantic Differential

The *Semantic Differential* instrument consisted of eleven 7-point scales defined by adjective pairs representing three factors: Evaluative, Potency, and Action. The rationale, construction, and analysis of this instrument has been described in Osgood, Suci, and Tannenbaum (1957).

Evaluative

good-bad
work-play
cruel-kind
pleasant-unpleasant

Potency

strong-weak
heavy-light
feminine-masculine

Activity

fast-slow
repetitious-varied
loud-soft
active-passive

The concept, "TEACHING MACHINE," was to be rated on each of the eleven scales. The scales were printed on mask sense forms so that scoring machines could be used to transfer the data to punched cards. A computer program was written for a Philco 2000 Computer to process these data. For each subject ratings on each factor were averaged. The program computed D's[1] for selected pairs of subpopulation of subjects.

Intelligence and Achievement Tests

The California Test of Mental Maturity Series Short-Form 1963 Revision scores were used to provide Total, Language, and Non-Language Intelligence Quotient scores. The California Achievement Tests were used to provide scores for Reading Vocabulary, Reading Comprehension, Arithmetic Reasoning, Arithmetic Fundamentals, Mechanics of English, and Spelling. The technical reports for these measures have been published by the California Test Bureau (1957, 1964).

Instructions

Several types of instructions were developed for use in the conduct of the experiment. Separate instructions were evolved for administering the experimental treatments, the F Battery, the performance test, and for scoring these latter test instruments. In general, they were required for orientation, transition, control, and record keeping.

Instructions for the experimental treatments. Directions were brief and read aloud to the students after they took their places at the teaching machines. Directions were

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[1] D's represent the distance between groups in the semantic space. The distance between two groups, i and j, is

$$D_{ij} = \sqrt{(E_i - E_j)^2 + (P_i - P_j)^2 + (A_i - A_j)^2}$$

Where E_i is the mean Evaluative for group;
P_i is the mean Potency for group;
A_i is the mean Activity for group; and
E_j, P_j, and A_j are similarly defined for group.

also provided on the teaching machine screen for the operation and methods of responding to be used while viewing the stimulus materials. Consequently, the directions read aloud by the staff member were integrated with the instructions being seen by the students. Opportunity was provided for the students to ask questions if the directions were unclear. Each student was monitored by the staff member as he proceeded through a trial use of the machine. Incorrect use of the machine was noted and remedial directions provided, when necessary.

F Battery. Directions for this measure were read aloud and students could follow along since the directions were printed in their test booklets. Constant observations were made during administration to insure that the students were viewing the correct page and marking their response sheets in the proper fashion. Students were permitted to ask questions if the instructions were not clear. Only those which did not disclose the subtle nature of the desired test responses were answered.

Performance Test. Directions were read aloud to all students. The directions were also provided on their response sheets. Students were permitted to ask questions regarding procedures and all students were monitored during the test to insure that the desired procedures were being followed. In any instance where the performance post-test or F Battery results indicated that a student had violated instructions, the data were not used.

Scoring. Identical understandings of criteria and procedures were deemed crucial in scoring the tests. Instructions were reviewed with all scorers and all tests were scored twice. After the first fifty tests were completed a review was made to verify accuracy of procedures and scoring. All scorers were located in rooms adjacent to the scorer-abritrator, and discrepancies in scoring were resolved as they arose. The intent of these procedures was to reduce errors, minimize bias that might be introduced, and maintain overall consistency in scoring.

Preparation of Data and Statistical Analysis

A wide range of data were collected during the course of this study. Preparation of them for analysis varied from manual tallying to elaborate sorting procedures on a computer, and from visual assessment to multivariate analysis by machine.

Recording the Data

Student log book. Student names and numbers assigned for the research were posted in the daily log book at the time the students were scheduled for test processing. When students appeared with their summons slips, their names were checked against the log book and they were seated at the appropriate teaching machine. Starting and completion times were recorded in the log book for all students. If irregularities in the administration of the stimulus materials were observed, these were also recorded in the log book and decisions to use or void the data for any given student were made. The log book was checked periodically during the day to insure that duplicate numbers had not been assigned.

Card punch response data. Provision was made in the design of the teaching machine system to record each student response as it was made. Data collected in this way included the choice made on each multiple-choice question, the time taken between choice, the branch entered, and the duration of each stimulus sequence for each subject. The system used to collect these data included circuits for recording up to a total of six subject identification numbers, a clock with associated logic for relating time to response selections made by each subject, and a Model 523 IBM card punch with logic required to place these data into IBM Hollerith cards in the proper format.

Response sheets. Response sheets were collected from every machine following each student's individual setting. Students were required to place their names on the sheet; then the program administrator added the appropriate student number along side the student's name. At the end of each week these sheets were organized into sets and stored according to individual schools to be used for later analyses.

Ethnic and occupation codes. The ethnic and occupation codes used in this experiment were created based on information obtained from student records and in consultation with guidance counselors at each school. Ethnic codes were checked as each student proceeded through the experimental phase and were applied to each student's post-test score sheet. When occupational data were not available on student records, guidance personnel interviewed students to obtain the required information. All ethnic and occupational designations were reviewed with guidance personnel prior to and during the experimental treatments. When difficulties occurred in determining the proper student codes to assign due to incomplete student cumulative records designations, these were discussed with the guidance counselors and student interviews held when required.

Descriptive data. Descriptive data collected for each student included total IQ, language IQ, non-language IQ, and achievement test scores for Vocabulary, Verbal Comprehension, Reasoning, Fundamentals of Mathematics, Mechanics of English, Spelling, Sex, and Age.

October, 1964 marked the latest test data available, as all the eighth grade students involved in the study had completed the California Test of Mental Maturity and the California Achievement Tests during that month. These data were provided by the central tests and measurement office of the Los Angeles Unified School District. Test results were available for ninety-eight percent of the eighth grade populations enrolled at each school. Where data were not available for the remaining two percent of the students at the individual schools, these students were not used as experimental subjects. Minimum recording and transfer of student data from cumulative records to experimental subject log sheet to Hollerith cards since printout sheets and punched cards were provided with data for the student populations by the school district test scoring office. Every tenth student's name and data listing were checked with original student records at each school location. Less than one-tenth of one percent error rate was noted.

Statistical Techniques and Computer Programs

Four main types of analyses were performed in this study: correlation, factor analysis, analysis of variance and covariance, and multiple-comparisons. An IBM 7094 computer, a Philco 2000 computer and an IBM 1401 computer were used in all analyses for which programs are described below.

The principal components factors analysis used provided means and standard deviations, a correlation matrix, and a factor matrix useful in the selection of covariates for later analyses. An orthogonal rotation to the varimax criterion was performed on the first seven factors. This program is described in the user's handbook of the Health Sciences Computing Facility, University of California, Los Angeles, under the title "BMD 03M, Factor Analysis" (Dixon, 1964).

Analyses of variance and covariance were undertaken to establish the statistical differences among the experimental variables and to adjust the test scores for differences among the groups in aptitude characteristics (total score on F Battery) and intelligence characteristics (total score on IQ). The computer program used was developed by the staff of the Health Sciences Computing Facility and is described in their handbook under the title "BMD 05V, General Linear Hypothesis" (Dixon, 1964). In conjunction with each analysis of variance, Bartlett's Test for Homogeneity of Variance and Welch's Test for Homogeneity of Means were performed as described in Snedecor (1956).

A program prepared by Villone, McCornack, and Wood of the System Development Corporation was used for the multiple regression with subsetting of variables.

Analysis of the response data from the card punch used specially prepared programs operated on an IBM 1401 computer.

Other special programs used in these analyses were prepared by D. Estavan, R. McCornack, C. Walker, and L. Villone of the System Development Corporation, Santa Monica, California. The basic formulation of the statistical techniques used is described in Snedecor (1956), Anderson (1959), Scheffé (1959), and Brownlee (1960).

Conducting the Experiment

F Battery

Administration of the Battery took place during a regularly scheduled science period. The science faculty at each junior high school had been oriented to the testing procedures and asked to decide upon a testing schedule agreeable to themselves. This was done to insure consistency of testing procedures from one science section to another as each teacher had to introduce the test administration by bringing the class to order and instructing the students to put away their books. The Battery was designed so that it could be administered in a single class period. This protected the students from unnecessary disturbance due to relocation or rescheduling. The subjects did not know in advance that the F Battery was to be administered. Each science teacher assisted in monitoring the test, collecting the tests, and verifying student names on test documents.

Faculty Briefings

Prior to conducting the experiment at any given junior high school, a presentation was made at a general faculty meeting to explain the nature of the research study and the extent of involvement planned for the eighth grade students. The theory of the research, the set-up of the teaching machines and the teaching trailer were all explained. Faculty members were invited to an open-house after the experimental trailer had been placed on the school campus. No discussion of the specific content was made in order to minimize any advance warning to their pupils. Subsequent special meetings were held to discuss in greater depth the nature of the participation required of science and guidance faculty with the research project.

Locating the Experimental Trailer

The trailer containing the teaching machines was located on each junior high school campus one to two weeks prior to conducting the student trials. This was done to allow for reliability checks of the equipment at each location and also to accustom teachers and students to seeing the 40-foot long vehicle on their campus. Location of the trailer in close proximity to classroom areas was an important criterion in order to reduce the time required for students to come from a classroom to the trailer.

At each junior high school students were encouraged to look into the trailer and see the teaching booths. This open-door policy was designed to reduce any secrecy or aura of mystery that might otherwise surround the campus "intruder." However, actual entrance to the trailer was only allowed when the students were participating in the experiment.

Daily Selection of Subjects

One student at a time was summoned from a regularly scheduled class period in order to minimize class disruptions. Numerous patterns were used in the selection of subjects to insure that students would not identify the system for selection and then anticipate the time when they would be called.

Each morning summons slips for the entire day were delivered by a staff member to the guidance office. Student office assistants distributed the slips to students the period before they were to visit the trailer. Slips for absent students were returned to the trailer and alternates, designated by the research staff, were called in their place.

Scheduling

Assignment of each student to the testing process was dependent upon the operating capability of the teaching machines. In general, if all the equipment was operating, a group of six students was assigned to the machines at one time. When they completed their instruction, six other students were seated at the teaching stations. Scheduling was dictated by the machines that were in operation.

Procedure for Experimental Treatments

Students were ushered to the teaching machine stations to which they had been assigned.and seated. They then had the opportunity to acquaint themselves with the environment of the station prior to having instructions read to them. Following completion of the teaching sequence presented on the teaching machine, a sequence designed and field-tested to provide instruction in the proper use of the machine, students were permitted to ask questions concerning correct operating procedures. As each student completed his segment he was assisted in folding the sheet on which he had written his constructed responses. Each student was asked to wait until at least two other students had completed their instruction and then they followed their guide to the room scheduled for the administration of the post-test.

Criterion Test Administration

Test booklets, answer sheets, and pencils were distributed. The test administrator reviewed the test procedures orally and then read aloud the instructions. When all the students had completed the questions in the test booklet, instructions for answering the film and slide questions were reviewed. The room lights were then dimmed, and the film or slide items were projected upon the screen. Sufficient light was available in the room for students to mark their answer sheets during a 10-second response period. Upon completion of all the items, the lights were turned up and answer sheets and pencils collected.

Transition from Test to Class Schedules

Student summons slips were signed and the students were instructed to return to their classes in progress at the time. Disruption of eighth grade class schedules was minimized by timing the teaching machine activity and post-test to occur between the beginning of classes and "nutrition periods," prior to lunch periods, or before the end of the school day. Since only six students were involved in either the instruction or testing phase at any one time and each student had a different schedule, transition back to class did not require the movement or flow of many students to any one class section.

CHAPTER IV

RESULTS: EXPERIMENT I

(NON-CONCRETE REFERENT MATERIAL)

The results of Experiment I, relating to the use of materials being inherently non-concrete in their referents, are organized into two sections: description of the test results and analysis of the test results for the principal variables being investigated. Later chapters will treat secondary variables as they relate to Experiment I.

A total of 388 subjects from Junior High School A and B participated in the experiment, 195 (50.3%) being boys and 193 (49.7%) being girls.

Description of Post-Test Results

Mean scores and standard deviations for the total performance post-test and for selected performance subtests are presented in Table 4. These data are presented for each treatment group and for the total population.

Examination of the total performance post-test scores for the eighteen treatment groups shows a range from 18.70 to 24.14 with a total mean of 22.19, the Still-Graphic/Directive/Linear treatment being most effective and the Print/Redundant/Linear, the least effective. On the seventeen verbal items of the performance post-test mean scores ranged from 9.00 to 10.32, on the five graphic items from 2.39 to 3.13, and on the four motion-picture items from 1.70 to 2.74. There was a slight tendency in the subtests for the higher scores to occur with the Motion Picture treatments.

TABLE 4

TOTAL POST-TEST AND SELECTED SUBTEST MEAN SCORES AND STANDARD DEVIATIONS FOR TREATMENT GROUPS AND TOTAL POPULATION (EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL)

Tests / Treatment Group	N	Total Score (35 items) $\bar{x}$	σ	Verbal (17 items) $\bar{x}$	σ	Graphic (5 items) $\bar{x}$	σ	Motion Picture (4 items) $\bar{x}$	σ
Print/Silent/Linear	26	21.27	8.40	9.62	2.40	2.62	1.20	2.04	.72
Print/Silent/Branching	21	20.10	6.71	9.33	2.37	2.48	1.33	1.95	1.02
Print/Redundant/Linear	20	18.70	6.78	9.50	2.62	3.13	1.15	2.13	.99
Print/Redundant/Branching	20	24.00	9.10	9.09	2.51	2.91	1.19	2.45	1.18
Print/Directive/Linear	24	22.79	7.53	9.35	2.72	2.50	1.05	1.70	.98
Print/Directive/Branching	22	22.14	6.24	9.90	2.99	2.80	1.36	2.00	1.08
Graphic/Silent/Linear	22	20.73	7.95	9.32	2.78	2.55	1.18	2.23	.87
Graphic/Silent/Branching	20	21.65	7.66	9.70	2.00	2.80	1.64	2.55	.69
Graphic/Redundant/Linear	19	23.10	6.05	9.95	2.48	2.90	1.34	2.48	.87
Graphic/Redundant/Branching	21	22.14	8.24	9.75	2.47	2.45	1.54	2.60	.94
Graphic/Directive/Linear	21	24.14	7.99	9.11	2.33	3.05	1.03	2.47	.77
Graphic/Directive/Branching	20	23.70	9.08	9.95	2.97	2.57	1.60	2.33	.80
Motion/Silent/Linear	23	23.61	9.59	10.26	3.45	3.04	1.49	2.70	1.11
Motion/Silent/Branching	19	22.84	7.73	10.05	2.70	2.47	1.47	2.42	.96
Motion/Redundant/Linear	23	21.95	7.20	9.61	2.92	2.39	1.41	2.43	.95
Motion/Redundant/Branching	22	23.73	7.69	9.05	2.65	2.82	1.05	2.64	.85
Motion/Directive/Linear	23	21.09	7.86	9.00	2.81	2.74	1.14	2.74	1.01
Motion/Directive/Branching	22	22.09	7.68	10.32	3.48	2.45	1.41	2.64	.95
Total	388	22.19	7.77	9.60	2.70	2.70	1.31	2.36	.96

Analysis of Post-Test Results

Test results were analyzed for total performance post-test scores using analysis of variance, Scheffe's test for multiple comparisons, analysis of covariance; and for the verbal, graphic, and film subtests separately, using the t-test and analysis of variance.

Selection of Covariates

Covariates for the analysis of covariance were selected by performing correlation and factor analyses of the test scores. Three criteria were used in the selection of the covariates. The first required that the covariates selected be meaningful in the context of the study to members of the educational community who might be using the reported results. Second, since only two covariates were to be used, it was important that one covariate have a large loading on one factor and the other covariate have a large loading on another factor. Third, these two covariates also had to have a low correlation with each other and a significant correlation with the total performance post-test.

The covariates selected were total IQ and total F Battery scores. Both the covariates selected were measurable by existing tests, thus meeting the first criterion. Examination of Table 5 shows that total IQ had a high loading (-.701) on Factor 4 and that total F Battery had a high loading (.894) on Factor 5. Table 59 in Appendix D shows these two covariates to have a .56 correlation with each other, which was moderate within the range of possible covariates to be considered. Sex and age were not considered as covariates because they correlated so low with the total performance post-test.

Correlation of Variables

Correlations listed in Appendix D for this experiment showed the post-test as being highly correlated with the total IQ score (.63), the language IQ score (.68), and the achievement scores for verbal comprehension (.72), vocabulary (.65), and arithmetic reasoning (.66). In general, all of the standardized measures, CTMM, and CAT correlated highly with the total post-test score. The part scores of the post-test

TABLE 5

ROTATED FACTOR LOADINGS USED AS A BASIS FOR SELECTING COVARIATES APPLIED IN THE ANALYSIS OF COVARIANCE (N = 388)

EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL

Variables	Factors							
	1	2	3	4	5	6	7	8
Total Post-Test	.397	.029	-.061	-.172	.172	-.268	-.802	.239
Total F Battery	.247	-.083	-.031	-.230	.894	-.210	-.133	.119
Sex	.004	.984	.062	-.075	-.059	.026	-.016	-.088
Age	-.113	.067	.977	.140	-.025	.050	.038	-.027
Language IQ	.786	-.001	-.196	-.289	.136	-.268	-.232	.168
Non-Language IQ	.185	.075	-.116	-.928	.171	-.192	-.080	.054
Total IQ	.558	.044	-.178	-.701	.174	-.264	-.181	.129
Vocabulary	.826	.024	-.048	-.154	.184	-.222	-.145	.317
Verbal Comprehension	.685	-.037	-.028	-.239	.174	-.464	-.256	.225
Arithmetic Reasoning	.496	.045	-.051	-.240	.194	-.685	-.204	.199
Arithmetic Fundamentals	.303	-.069	-.060	-.230	.166	-.817	-.154	.249
English Mechanics	.504	-.263	-.096	-.230	.242	-.378	-.096	.488
Spelling	.358	-.100	-.021	-.057	.094	-.264	-.199	.839

exhibited a positive relationship to the intelligence and achievement scores in varying degrees (.20 to .67). On the other hand, sex (.02) and age (.18) had low correlations with the post-test scores, and the F Battery had a .48 correlation.

The total F Battery correlations with IQ and achievement scores were in the medium range (.39 to .56) and its correlation with sex was low (.13). As might be expected, total IQ correlated highly with the achievement scores (.48 to .84).

Analysis of Total Post-Test Scores

Two analyses of variance were performed on these data, one with the two covariates (total IQ and total F Battery) and one without. This schedule of analyses permitted estimates to be made of the effects of the covariates upon the unadjusted data. In addition, comparisons of individual variable performance test means were performed using Scheffé's test for multiple comparisons (1953, 1959). These tests permitted comparisons of selected variables and combinations of variables within the variance and covariance analyses. Table 6 presents the means for the interactions among all the variables, both unadjusted and adjusted, for the total performance post-test scores.

The results of the analyses of variance and of covariance are presented in Tables 7 and 8. In both the analysis of variance and analysis of covariance, the null hypothesis was accepted in all cases, no significant differences being found among the major sources of variation. However, when adjustments were made in the mean scores for the total IQ and total F Battery covariates, some increase in significance was apparent in three comparisons. Comparison of the results of the analysis of covariance with those of the analysis of variance (no covariates) shows that the differences (apparent but non-significant) among the visual ($p < .25$) and programing ($p < .10$) presentation modes and interactions between the visual and audio presentation modes ($p < .25$) required adjustment before they became evident. However, these differences were not significant enough to warrant further analysis. The general conclusion may be made that the analyses of the major variables for material

TABLE 6

TOTAL POST-TEST UNADJUSTED AND ADJUSTED MEAN SCORES (COVARIATES: TOTAL IQ AND TOTAL F BATTERY) EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL

	N	Unadjusted	Adjusted
Visual Presentation Mode			
Printed Verbal	133	21.53	21.67
Still Graphic	123	22.55	22.17
Motion Picture	132	22.54	22.69
Audio Presentation Mode			
Silent	131	21.69	21.63
Redundant	125	22.28	21.94
Directive	132	22.62	22.93
Programing Mode			
Linear	201	21.94	22.34
Branching	187	22.48	21.99
Combined Modes			
Print/Silent/Linear	26	21.27	21.56
Print/Silent/Branching	21	20.10	19.10
Print/Redundant/Linear	20	18.70	18.15
Print/Redundant/Branching	20	24.00	24.03
Print/Directive/Linear	24	22.79	23.79
Print/Directive/Branching	22	22.14	22.97
Graphic/Silent/Linear	22	20.73	21.34
Graphic/Silent/Branching	20	21.65	20.57
Graphic/Redundant/Linear	19	23.10	22.86
Graphic/Redundant/Branching	21	22.14	20.52
Graphic/Directive/Linear	21	24.14	24.24
Graphic/Directive/Branching	20	23.70	23.66
Motion/Silent/Linear	23	23.61	24.33
Motion/Silent/Branching	19	22.84	22.74
Motion/Redundant/Linear	23	21.95	22.92
Motion/Redundant/Branching	22	23.73	23.06
Motion/Directive/Linear	23	21.09	21.62
Motion/Directive/Branching	22	22.09	21.44

TABLE 6 (continued)

	N	Unadjusted	Adjusted
Visual-Audio Modes			
Print/Silent	47	20.74	20.47
Print/Redundant	40	21.35	21.10
Print/Directive	46	22.48	23.39
Graphic/Silent	42	21.17	20.95
Graphic/Redundant	40	22.60	21.63
Graphic/Directive	41	23.93	23.95
Motion/Silent	42	23.26	23.62
Motion/Redundant	45	22.82	22.98
Motion/Directive	45	21.58	21.53
Visual-Programing Modes			
Print/Linear	70	21.06	21.36
Print/Branching	63	22.05	22.02
Graphic/Linear	62	22.61	22.77
Graphic/Branching	61	22.49	21.56
Motion/Linear	69	22.22	22.96
Motion/Branching	63	22.89	22.40
Audio-Programing Modes			
Silent/Linear	71	21.86	22.39
Silent/Branching	60	21.48	20.73
Redundant/Linear	62	21.26	21.35
Redundant/Branching	63	23.29	22.48
Directive/Linear	68	22.63	23.19
Directive/Branching	64	22.61	22.66
TOTAL	388	22.19	22.18

TABLE 7

TOTAL POST-TEST RESULTS (ANALYSIS OF VARIANCE)
EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL

Source of Variation	df	SS	MS	F	Prob.
Visual Modes (PV:SG:MP)	2	98.631	49.316	.807	-----
Audio Modes (S:R:D)	2	60.791	30.396	.497	-----
Programing Modes (L:B)	1	29.703	29.703	.486	-----
Visual (PV:SG:MP) x Programing (L:B)	2	28.065	14.033	.229	-----
Audio (S:R:D) x Programing (L:B)	2	105.459	52.730	.863	-----
Visual (PV:SG:MP) x Audio (S:R:D)	4	233.664	58.416	.956	-----
Visual (PV:SG:MP) x Audio (S:R:D) x Programing (L:B)	4	219.625	54.906	.898	-----
Within	370	22610.703	61.110		

TABLE 8

TOTAL POST-TEST RESULTS (ANALYSIS OF COVARIANCE)
(COVARIATES: TOTAL IQ AND TOTAL F BATTERY)
EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL

Source of Variation	df	SS	MS	F	Prob.
Visual Modes (PV:SG:MP)	2	105.955	52.978	1.494	<.25
Audio Modes (S:R:D)	2	20.748	10.374	.293	-----
Programing Modes	1	103.637	103.637	2.922	<.10
Visual (PV:SG:MP) x Programing (L:B)	2	11.233	56.170	.158	-----
Audio (S:R:D) x Programing (L:B)	2	42.500	21.250	.599	-----
Visual (PV:SG:MP) x Audio (S:R:D)	4	215.750	53.938	1.521	<.25
Visual (PV:SG:MP) x Audio (S:R:D) x Programing (L:B)	4	106.553	26.638	.571	-----
Within	368	13050.775	35.464		

comprising a maximum of emphasis on non-concrete referents demonstrated no significant differences favoring any of the presentation modes.

Comparison of individual post-test means was done by using Scheffé's test for multiple comparisons (Scheffé, 1953, 1959), as presented in Table 9. The conservative nature of this multiple comparison technique in psychological research, as contrasted to other similar techniques, is discussed at length by Ryan (1959). Several significant interactions for the adjusted scores were revealed among the combinations of selected variables. The directive sound, when used in concert with the print and graphic materials, was a more effective presentation combination than either the redunant or silent modes used in conjunction with the print and graphic modes ($p < .01$, $p < .05$). In the case of the motion and sound presentations, however, the pattern deviated from the two other visual-sound mixes. The only comparison approaching the significance level was the directive and silent motion presentation and, this favored the silent treatment ($p < .10$). There was some evidence also that the silent mode of audio presentation was more effective when combined with the linear than with the branching programing mode ($p < .05$).

Analysis of Selected Subtest Scores

Three of the five subtests in Experiment I were selected for separate analysis in order to determine the existence of any relationships between the mode of stimulus presentation and the mode of performance testing used. These three subtests (comprising 26 of the 35 items in the performance post-test) used test questions that could be described as verbal fill-in and multiple-choice (17 items), graphic fill-in and multiple-choice (5 items), and motion picture multiple-choice (4 items). The verbal questions used words only; the graphic questions used graphic illustrative material as integral parts of the questions; the motion picture questions used projected filmed sequences as integral parts of the questions. Table 10 presents the unadjusted mean scores and standard deviations of the three subtests for the major variables under study.

To support the stimulus generalization hypothesis that learning of presented information increases as the

TABLE 9

COMPARISON OF INDIVIDUAL POST-TEST MEANS USING SCHEFFÉ'S TEST FOR MULTIPLE COMPARISONS (EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL)

Comparisons	Unadjusted		Adjusted	
Print/Silent vs. Print/Directive	20.74	22.48	20.47	23.39[a]
Print/Redundant vs. Print/Directive	21.35	22.48	21[illegible]	23.39[c]
Graphic/Silent vs. Graphic/Directive	21.17	23.93[c]	20.95	23.95[a]
Graphic/Redundant vs. Graphic/Directive	22.60	23.93	21.63	23.95[b]
Motion/Directive vs. Motion/Silent	21.58	23.26	21.53	23.62[c]
Silent/Branching vs. Silent/Linear	21.48	21.86	20.73	22.39[b]
Redundant/Linear vs. Redundant/Branching	21.26	23.29[c]	21.35	22.48

[a] $p < .01$; [b] $p < .05$; [c] $p < .10$

TABLE 10

COMPARISON OF UNADJUSTED MEAN SCORES AND STANDARD DEVIATIONS FOR VERBAL, GRAPHIC, AND MOTION PICTURE PERFORMANCE SUBTESTS (EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL)

	N	Verbal Items (17)		Graphic Items (5)		Motion Picture Items (4)	
		$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Visual Presentation Mode							
Printed-Verbal	133	9.47	2.42	2.73	1.23	2.03	1.02
Still-Graphic	123	9.62	2.54	2.71	1.43	2.45	0.81
Motion-Picture	132	9.70	3.09	2.66	1.35	2.60	0.98
Audio Presentation Mode							
Silent	131	9.71	2.69	2.66	1.41	2.31	0.93
Redundant	125	9.49	2.63	2.75	1.33	2.44	1.03
Directive	132	9.59	2.99	2.69	1.27	2.31	1.00
Programing Mode							
Linear	201	9.53	2.68	2.76	1.24	2.32	0.96
Branching	187	9.68	2.76	2.64	1.42	2.40	0.97
TOTAL	388	9.60	2.70	2.70	1.31	2.36	0.96

testing situation becomes more similar to the presentation situation, it would be expected that higher post-test performance would be achieved on the verbal items for the printed-verbal presentation mode, on the graphic items for the still-graphic presentation mode, and on the motion-picture items for the motion-picture presentation mode. Only on the motion-picture items was this hypothesis supported. When compared by t-test, the subjects exposed to either the motion-picture or still-graphic presentation mode performed significantly better ($p < .01$) on the four motion-picture post-test items than did those exposed to the printed-verbal presentation mode. On the graphic post-test items no differences were found; and on the verbal items the data showed results contrary to prediction, the motion-picture and still-graphic groups performing at a higher (but non-significant) level than the printed-verbal group.

In a further analysis of variance for all eighteen experimental treatments, as shown in Table 11, larger F values were associated with positive relationships between motion-picture stimuli and motion-picture test items and negative relationships between printed-verbal stimuli and motion-picture test items. No other patterns were discernible.

TABLE 11

COMPARISON OF F VALUES, PERCENT OF VARIATION ATTRIBUTABLE TO TEST ITEM TYPE, AND RELATIONSHIP TO MEAN SCORE IN TOTAL POPULATION FOR SELECTED PERFORMANCE SUBTESTS (ANALYSIS OF VARIANCE) (EXPERIMENT I: NON-CONCRETE REFERENT MATERIAL)

	Verbal (17 items)			Graphic (5 items)			Motion Picture (4 items)		
	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population
Print/Silent/Linear	.001	0.00	+.02	.134	0.03	-.09	3.152	0.81	+.32
Print/Silent/Branching	.216	0.06	-.27	.683	0.18	-.23	4.041^{b}	1.04	-.41
Print/Redundant/Linear	.181	0.05	-.25	.521	0.14	-.21	10.206^{a}	2.69	-.66
Print/Redundant/Branching	.258	0.07	+.30	.108	0.03	+.09	2.987	0.77	-.36
Print/Directive/Linear	.035	0.01	-.10	2.624	0.67	+.42	1.542	0.40	-.24
Print/Directive/Branching	.838	0.21	+.51	.559	0.14	+.20	.221	0.06	+.09
Graphic/Silent/Linear	.254	0.07	-.28	.350	0.09	-.16	.450	0.12	-.13
Graphic/Silent/Branching	.028	0.01	+.10	.108	0.03	+.09	.817	0.21	+.19
Graphic/Redundant/Linear	.670	0.18	-.50	1.400	0.36	+.35	.275	0.07	+.11
Graphic/Redundant/Branching	.375	0.10	+.35	.234	0.06	-.14	.018	0.00	-.03
Graphic/Directive/Linear	.375	0.10	+.35	.509	0.13	+.20	.319	0.08	+.12
Graphic/Directive/Branching	.064	0.02	+.15	.806	0.21	-.26	1.307	0.35	+.24
Motion/Silent/Linear	1.460	0.37	+.66	1.623	0.42	+.34	2.983	0.78	+.34
Motion/Silent/Branching	.558	0.14	+.45	.628	0.16	-.23	.078	0.02	+.06
Motion/Redundant/Linear	1.207	0.31	-.60	.015	0.00	+.03	3.815	0.98	+.38
Motion/Redundant/Branching	1.646	.042	+.72	.860	0.22	-.25	1.921	0.49	+.28
Motion/Directive/Linear	.000	0.00	+.01	1.413	0.36	-.32	.144	0.04	+.07
Motion/Directive/Branching	.983	0.25	-.56	.170	0.04	+.11	1.921	0.49	+.28

$^{a}p < .01$; $^{b}p < .05$

CHAPTER V

RESULTS: EXPERIMENT II

(CONCRETE REFERENT MATERIAL)

The results of Experiment II, relating to the use of materials being inherently concrete in their referents, are organized into two sections: description of the test results and analysis of the test results for the principal variables being investigated. Later chapters will treat secondary variables as they relate to Experiment II.

A total of 411 subjects from Junior High Schools A, B, and C participated in the experiment, 191 (46.7%) being boys and 220 (53.3%) being girls.

Description of Post-Test Results

Mean scores and standard deviations for the total performance post-test and for selected performance subtests are presented in Table 12. These data are presented for each treatment group and for the total population.

Examination of the total performance post-test scores for the eighteen treatment groups shows a range from 27.24 to 35.83 with a total mean of 31.86. The Motion/Redundant/Branching and the Graphic/Silent/Branching treatments were the most effective, and the Print/Redundant/Linear and the Print/Redundant/Branching treatments were the least effective. On the eight verbal items of the post-test mean scores ranged from 3.82 to 4.91, on the sixteen graphic items from 8.90 to 12.33, on the four motion-picture items from 2.71 to 3.44, on the six slide naming items from 1.40 to 2.95, and on the six slide matching items from 2.30 to 4.50. There was a decided tendency in the pictorial items (graphic, motion, and slide)

TABLE 12

TOTAL AND SELECTED SUBTEST MEAN SCORES AND STANDARD DEVIATIONS FOR TREATMENT GROUPS AND TOTAL POPULATION (EXPERIMENT II: CONCRETE REFERENT MATERIAL)

Tests / Treatment Group	N	Total (49 items)		Verbal (8 items)		Graphic (16 items)		Motion Picture (4 items)		Slide Presentation (12) Naming (6)		Slide Presentation (12) Matching (6)	
		$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Print/Silent/Linear	25	28.52	9.41	4.44	2.14	9.92	3.67	2.88	.93	1.88	1.53	2.40	1.63
Print/Silent/Branching	20	30.45	8.50	4.50	2.14	10.30	2.85	3.10	1.07	1.90	1.20	3.30	1.49
Print/Redundant/Linear	25	27.24	7.20	4.78	2.07	10.65	3.72	2.87	1.06	1.40	1.08	2.44	1.04
Print/Redundant/Branching	20	27.35	10.37	4.91	1.68	10.22	3.45	3.04	.82	1.85	2.10	3.05	1.60
Print/Directive/Linear	23	30.91	9.41	4.56	2.02	9.16	3.01	2.92	.76	2.34	1.99	2.30	1.29
Print/Directive/Branching	23	31.13	7.86	4.10	2.05	8.90	3.57	2.90	1.02	2.26	1.45	2.43	1.77
Graphic/Silent/Linear	24	30.38	10.19	4.88	1.78	10.42	3.36	2.92	1.02	2.33	1.85	3.29	1.29
Graphic/Silent/Branching	21	34.67	8.13	4.10	1.92	12.29	3.47	3.10	.70	2.66	1.55	4.28	1.10
Graphic/Redundant/Linear	24	31.42	9.42	4.09	1.72	12.14	2.59	2.86	.83	2.37	1.90	3.58	1.41
Graphic/Redundant/Branching	23	32.57	9.09	4.17	1.97	11.96	3.07	2.96	.81	2.65	1.61	3.82	1.46
Graphic/Directive/Linear	22	32.68	7.89	3.92	2.04	11.13	3.95	2.96	1.00	2.45	1.73	3.77	1.37
Graphic/Directive/Branching	24	34.00	7.98	4.26	1.84	11.43	3.58	2.87	.92	2.95	1.60	4.25	1.25
Motion/Silent/Linear	24	33.54	8.86	4.17	1.74	11.79	3.65	3.21	.72	2.83	1.83	3.50	1.74
Motion/Silent/Branching	24	33.25	10.42	4.63	1.81	11.83	3.89	2.71	.95	2.83	1.92	3.87	1.59
Motion/Redundant/Linear	25	33.44	10.18	3.82	1.89	11.91	2.74	3.00	.93	2.68	1.97	3.56	1.68
Motion/Redundant/Branching	24	35.83	8.80	4.11	2.25	12.33	3.31	3.06	.94	2.75	1.79	4.50	1.38
Motion/Directive/Linear	22	30.05	7.56	4.20	1.53	11.68	3.83	3.44	.77	2.45	1.29	4.00	1.48
Motion/Directive/Branching	18	33.17	9.52	4.67	2.16	12.33	3.38	3.29	.86	2.77	1.35	3.94	1.47
Total	411	31.86	9.10	4.36	1.92	11.12	3.52	3.00	.92	2.41	1.70	3.45	1.62

for the higher scores to occur with the still-graphic and motion-picture treatments.

Analysis of Post-Test Results

Test results were analyzed for total performance post-test scores using analysis of variance, analysis of covariance; and Scheffé's test for multiple comparisons; and for the verbal, graphic, motion, and slide presentation subtests separately, using the t-test and analysis of variance.

Selection of Covariates

Covariates for the analysis of covariance were selected by performing correlation and factor analyses of the test scores, using the three criteria described in Experiment I. The same covariates were selected as in Experiment I: total IQ and total F Battery scores.

An examination of Table 13 shows that total IQ had a high factor loading (-.630) on Factor 5 and that total F Battery had a high loading (.871) on Factor 4. Table 60 in Appendix D shows these two covariates to have a .63 correlation with each other, which was moderate within the range of possible covariates to be considered. Sex and age were not considered as covariates because they correlated so low with the total performance post-test.

Correlation of Variables

The correlation of the post-test with the intelligence and achievement tests showed a striking resemblance to the pattern provided in Experiment I. The post-test is correlated highly with the total IQ score (.66), the language IQ score (.68), and for all the achievement scores (.63 to .76). The part scores of the post-test correlated with total IQ in a range from .32 to .58 and with different parts of the California Achievement Test in a range from .29 to .66. The F Battery had a .53 correlation with total post-test. However, sex (.00 to .15) and age (.11 to .26) had low correlations with the total post-test and its subparts.

The total F Battery correlations with IQ and achievement scores were in the medium high range (.41 to .63), and

TABLE 13

ROTATED FACTOR LOADING USED AS A BASIS FOR SELECTING COVARIATES APPLIED IN THE ANALYSIS OF COVARIANCE (N = 411) EXPERIMENT II: CONCRETE REFERENT MATERIAL

Variables	Factors							
	1	2	3	4	5	6	7	8
Total Post-Test	.448	-.050	.088	.173	-.181	.772	-.290	-.201
Total F Battery	.312	-.021	.009	.871	-.257	.131	-.220	-.089
Sex	.036	.984	-.078	-.014	-.088	-.026	.005	.111
Age	-.153	.090	-.958	-.009	.179	-.052	.063	.088
Language IQ	.826	.067	.247	.166	-.248	.146	-.253	-.147
Non-Language IQ	.208	.095	.177	.206	-.893	.113	-.217	-.095
Total IQ	.606	.094	.247	.212	-.630	.146	-.267	-.138
Vocabulary	.806	-.008	.056	.232	-.144	.210	-.248	-.258
Verbal Comprehension	.691	.029	.065	.187	-.216	.283	-.442	-.233
Arithmetic Reasoning	.555	.058	.091	.197	-.214	.184	-.676	-.157
Arithmetic Fundamentals	.373	-.030	.072	.197	-.280	.187	-.769	-.229
English Mechanics	.543	-.180	.073	.271	-.211	.263	-.430	-.386
Spelling	.415	-.206	.149	.091	-.133	.178	-.278	-.781

its correlation with sex was low (.02). As might be expected, total IQ correlated highly with the achievement scores (.59 to .79).

Analysis of Total Post-Test Scores

Two analyses of variance were performed on these data, one with two covariates (total IQ and total F Battery) and one without. This schedule of analysis permitted estimates to be made of the effects of the covariates upon the unadjusted data. In addition, comparisons of individual variable performance test means were performed using Scheffé's test for multiple comparisons (1953, 1959). These tests permitted comparisons of selected variables and combinations of variables within the variance and covariance analyses. Table 14 presents the means for the interactions among all the variables, both unadjusted and adjusted, for the total performance post-test scores.

The results of the analyses of variance and covariance are presented in Tables 15 and 16. The results of both the analysis of variance and analysis of covariance showed the variation among the visual presentation modes to be highly significant ($p < .001$). Significant differences were also found, after adjustment for the programing modes ($p < .05$), and for the interactions between the visual presentation and programing modes ($p < .05$). The variation among the audio presentation modes was not statistically significant.

When multiple comparisons using the Scheffé test (1953, 1959) were accomplished (Table 17), the motion-picture and still-graphic modes of visual presentation were significantly more effective than the printed-verbal mode of presentation ($p < .01$) in both the unadjusted score and adjusted score analyses. For the adjusted data, the difference was a 4.54 (15%) test point superiority for the motion-picture mode over the printed-verbal mode, and a 2.93 (10%) test point superiority for the still-graphic mode over the printed-verbal mode. There was a tendency ($p < .10$) for the motion-picture mode to be more effective than the still-graphic mode.

Directive sound appeared to be more effective than redundant sound when used with printed material ($p < .05$), whereas the redundant sound was more effective than the directive sound when used with motion-picture stimuli ($p < .10$).

TABLE 14

TOTAL POST-TEST UNADJUSTED AND ADJUSTED MEAN SCORES
(COVARIATES: TOTAL IQ AND TOTAL F BATTERY)
EXPERIMENT II: CONCRETE REFERENT MATERIAL

	N	Unadjusted	Adjusted
Visual Presentation Mode			
Printed Verbal	136	29.24	29.48
Still Graphic	138	32.57	32.41
Motion Picture	137	33.74	34.02
Audio Presentation Mode			
Silent	138	31.75	31.96
Redundant	141	31.39	31.70
Directive	132	32.47	32.29
Programing Mode			
Linear	214	31.19	31.29
Branching	197	32.58	32.73
Combined Modes			
Print/Silent/Linear	25	28.52	27.38
Print/Silent/Branching	20	30.45	32.16
Print/Redundant/Linear	25	27.24	28.59
Print/Redundant/Branching	20	27.35	27.47
Print/Directive/Linear	23	30.91	29.96
Print/Directive/Branching	23	31.13	31.65
Graphic/Silent/Linear	24	30.38	30.67
Graphic/Silent/Branching	21	34.67	34.77
Graphic/Redundant/Linear	24	31.42	31.56
Graphic/Redundant/Branching	23	32.57	31.64
Graphic/Directive/Linear	22	32.68	33.16
Graphic/Directive/Branching	24	34.00	32.95
Motion/Silent/Linear	24	33.54	34.09
Motion/Silent/Branching	24	33.25	33.25
Motion/Redundant/Linear	25	33.44	33.82
Motion/Redundant/Branching	24	35.83	36.46
Motion/Directive/Linear	22	33.05	32.68
Motion/Directive/Branching	18	33.17	33.60

TABLE 14 (continued)

	N	Unadjusted	Adjusted
Visual-Audio Modes			
Print/Silent	45	29.38	29.51
Print/Redundant	45	27.29	28.09
Print/Directive	46	31.02	30.80
Graphic/Silent	45	32.38	32.58
Graphic/Redundant	47	31.98	31.60
Graphic/Directive	46	33.37	33.07
Motion/Silent	48	33.40	33.67
Motion/Redundant	49	34.59	35.12
Motion/Directive	40	33.10	33.10
Visual-Programing Modes			
Print/Linear	73	28.84	28.52
Print/Branching	63	29.71	30.32
Graphic/Linear	70	31.46	31.76
Graphic/Branching	68	33.72	33.07
Motion/Linear	71	33.35	33.56
Motion/Branching	66	34.20	34.52
Audio-Programing Modes			
Silent/Linear	73	30.78	30.67
Silent/Branching	65	32.85	33.40
Redundant/Linear	74	30.69	31.32
Redundant/Branching	67	32.16	32.12
Directive/Linear	67	32.19	31.91
Directive/Branching	65	32.75	32.68
TOTAL	411	31.86	31.98

TABLE 15

TOTAL POST-TEST RESULTS (ANALYSIS OF VARIANCE)
EXPERIMENT II: CONCRETE REFERENT MATERIAL

Source of Variation	df	SS	MS	F	Prob.
Visual Modes (P:G:M)	2	1450.063	725.032	8.975	<.001
Audio Modes (S:R:D)	2	95.115	47.558	.589	-----
Programing Modes (L:B)	1	158.974	158.974	1.968	<.25
Visual (P:G:M) x Programing (L:B)	2	51.713	25.857	.320	-----
Audio (S:R:D) x Programing (L:B)	2	34.053	17.027	.211	-----
Visual (P:G:M) x Audio (S:R:D)	4	321.142	80.286	.994	-----
Visual (P:G:M) x Audio (S:R:D) x Programing (L:B)	4	111.962	27.991	.346	-----
Within	393	31748.691	80.785		

TABLE 16

TOTAL POST-TEST RESULTS (ANALYSIS OF COVARIANCE)
(COVARIATES: TOTAL IQ AND TOTAL F BATTERY)
EXPERIMENT II: CONCRETE REFERENT MATERIAL

Source of Variation	df	SS	MS	F	Prob.
Visual Modes (P:G:M)	2	1525.032	762.516	18.687	<.001
Audio Modes (S:R:D)	2	55.106	27.553	.675	-----
Programing Modes (L:B)	1	180.344	180.344	4.420	<.05
Visual (P:G:M) x Programing (L:B)	2	316.942	158.471	3.884	<.05
Audio (S:R:D) x Programing (L:B)	2	9.567	4.784	.117	-----
Visual (P:G:M) x Audio (S:R:D)	4	153.575	38.394	.941	-----
Visual (P:G:M) x Audio (S:R:D) x Programing (L:B)	4	178.024	44.506	1.091	-----
Within	391	15954.816	40.805		

TABLE 17

COMPARISON OF INDIVIDUAL POST-TEST MEANS USING SCHEFFÉ'S TEST FOR MULTIPLE COMPARISONS (EXPERIMENT II: CONCRETE REFERENT MATERIAL)

Comparisons	Unadjusted		Adjusted	
Print-Verbal vs. Still-Graphic	29.24	32.57[a]	29.48	32.41[a]
Print-Verbal vs. Motion-Picture	29.24	33.74[a]	29.48	34.02[a]
Still-Graphic vs. Motion-Picture	32.57	33.74	32.41	34.02[c]
Print/Redundant vs. Print/Directive	27.29	31.02[c]	28.09	30.80[b]
Motion/Silent vs. Motion/Redundant	33.40	34.59	33.67	35.12[c]
Motion/Directive vs. Motion/Redundant	33.10	34.59[c]	33.10	35.12[c]
Graphic/Linear vs. Graphic/Branching	31.46	33.72[c]	31.76	33.07[b]
Silent/Linear vs. Silent/Branching	30.78	32.85[c]	30.67	33.40[a]
Redundant/Linear vs. Redundant/Branching	30.69	32.16[c]	31.32	32.12

[a] $p < .01$; [b] $p < .05$; [c] $p < .10$

The branching-linear interaction favored the branching treatment only in the visual presentation of still-graphic stimuli ($p < .05$). When the silent and redundant sound unadjusted means were examined in relation to the programing modes, branching was more effective for both at the .10 level. When the adjusted means were compared, only the silent version obtained a level of significance in favor of branching, and this was at the .01 level.

Whereas in the first experiment a strong indication for a visual source of variation had not been recorded, this experiment indicated that non-verbal treatments (still-graphic and motion-picture) were significantly better than completely verbal presentations. The brief for a particular brand of sound was less distinct, in fact somewhat garbled, as contrasted to Experiment I wherein directive sound seemed to be more effective. The indication in Experiment I that the branching mode was more effective than the linear was substantiated more conclusively in Experiment II.

Analysis of Selected Subtest Scores

Five of the six subtests in Experiment II were selected for separate analysis in order to determine the existence of any relationships between the mode of stimulus presentation and the mode of performance testing used. These five subtests (comprising 40 of the 49 items in the performance post-test) used test questions that could be described as verbal fill-in and multiple-choice (8 items), graphic fill-in and multiple-choice (16 items), motion-picture multiple-choice (4 items), and slide presentations of line drawings or color photographs which required the identification of crystals by naming them in a constructed response (6 items) and the matching of pictures of crystals to names of crystals (6 items). The verbal questions used words only; the graphic questions used graphic illustrative material as integral parts of the questions; the motion-picture questions used projected filmed sequences as integral parts of the questions; and the slide presentations used projected slides as the principal stimuli for the questions. Table 18 presents the unadjusted mean scores and standard deviations of the five subtests for the major variables under study, and Tables 19 and 20 present the results of t-test comparisons between the visual presentation modes for selected subtest scores.

TABLE 18

COMPARISON OF UNADJUSTED MEAN SCORES AND STANDARD DEVIATIONS FOR VERBAL, GRAPHIC, MOTION PICTURE, AND SLIDE PRESENTATION PERFORMANCE SUBTESTS (EXPERIMENT II: CONCRETE REFERENT MATERIAL)

	N	Verbal Items (8)		Graphic Items (16)		Motion Picture Items (4)		Slide Presentation Items (12)			
								Naming (6)		Matching (6)	
		$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Visual Presentation Mode											
Printed-Verbal	136	4.54	1.98	9.85	3.55	2.95	.94	1.93	1.62	2.55	1.65
Still-Graphic	138	4.24	1.77	11.54	3.46	2.94	.90	2.47	1.73	3.82	1.60
Motion-Picture	137	4.25	1.92	11.97	3.49	3.10	.91	2.72	1.74	3.89	1.60
Audio Presentation Mode											
Silent	138	4.46	1.94	11.08	3.69	2.98	.92	2.41	1.73	3.35	1.75
Redundant	141	4.30	1.85	11.56	3.28	2.96	.92	2.39	1.69	3.50	1.56
Directive	132	4.27	1.97	10.71	3.78	3.05	.93	2.54	1.60	3.43	1.65
Programing Mode											
Linear	214	4.32	1.84	10.98	3.53	3.00	.92	2.30	1.75	3.14	1.67
Branching	197	4.37	2.01	11.29	3.65	3.00	.89	2.53	1.69	3.73	1.59
TOTAL	411	4.36	1.92	11.12	3.52	3.00	.92	2.41	1.70	3.45	1.62

TABLE 19

COMPARISON OF SCORES ON GRAPHIC AND VERBAL SUBTESTS FOR SUBJECTS RECEIVING EITHER A GRAPHIC OR VERBAL PROGRAM

Mode of Presentation	N	Mode of Testing							
		Graphic (16 items)		Naming (6 items)		Matching (6 items)		Verbal (8 items)	
		$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Still-Graphic	138	11.54	3.46	2.57	1.73	3.82	1.60	4.24	1.77
Printed-Verbal	136	9.85	3.55	1.93	1.62	2.55	1.65	4.54	1.98
Analysis of difference in gains between groups		$t = 3.99$ $p < .001$		$t = 3.20$ $p < .01$		$t = 6.47$ $p < .001$		$t = 1.32$ $p < .20$	

TABLE 20

COMPARISON OF SCORES ON GRAPHIC AND VERBAL SUBTESTS FOR SUBJECTS RECEIVING EITHER A MOTION-PICTURE OR VERBAL PROGRAM

Mode of Presentation	N	Mode of Testing									
		Graphic (16 items)		Naming (6 items)		Matching (6 items)		Motion-Picture (4 items)		Verbal (8 items)	
		$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Motion-Picture	137	11.97	3.49	2.72	1.74	3.89	1.60	3.10	.91	4.25	1.92
Printed-Verbal	136	9.85	3.55	1.93	1.62	2.55	1.65	2.95	.94	4.54	1.98
Analysis of difference in gains between groups		$t = 5.06$ $p < .001$		$t = 3.90$ $p < .001$		$t = 6.80$ $p < .001$		$t = 1.34$ $p < .20$		$t = 1.23$ $p < .20$	

These data showed strong support for the stimulus generalization hypothesis that learning of presented information increases as the testing situation becomes more similar to the presentation situation. On the three graphic subtests, the subjects exposed to either the still-graphic or motion-picture presentation mode performed significantly better than did those exposed to the printed-verbal presentation mode. Of the six comparisons, five were significant at the .001 level and one was significant at the .01 level. Also, with the four motion-picture subtest items, the motion-picture group showed superior but nonsignificant performance to the printed-verbal and the still-graphic groups ($p < .20$); and with eight verbal subtest items, the printed-verbal group showed superior but nonsignificant performance to the still-graphic and motion-picture groups ($p < .20$). Although some of these differences were not statistically significant, they were all in the direction predicted by the stimulus generalization hypothesis.

One other interaction was found to be statistically significant. On the six matching items of slide presentation post-test, the branching programing mode was superior to the linear mode ($p < .01$).

In a further analysis of variance for all eighteen experimental treatments, as shown in Table 21, larger F values were associated with positive relationships between the still-graphic and the motion-picture presentation stimuli and the graphic and pictorial slide presentation subtests. High positive F value relationships were also found between the motion-picture presentation stimuli and the motion-picture test items, and fairly high F value relationships were revealed for printed-verbal presentation stimuli and the verbal test items. On the other hand, negative relationships were shown between still-graphic and motion-picture stimuli and the verbal test items, and between the printed-verbal stimuli and the graphic, slide presentation, and motion-picture test items.

The most dramatic finding was that for the printed-verbal presentation groups who received redundant sound implementation in their performance on the graphic-pictorial subtests. Four out of the six comparisons were highly significant, showing negative relationships between this mode of presentation and the graphic testing mode. Why this particular combination of variables should react negatively with graphic testing is not known. All of these relationships

TABLE 21

COMPARISON OF F VALUES, PERCENT OF VARIATION ATTRIBUTABLE TO TEST ITEM TYPE, AND RELATIONSHIP TO MEAN SCORE IN TOTAL POPULATION FOR SELECTED PERFORMANCE SUBTESTS (ANALYSIS OF VARIANCE) (EXPERIMENT II: CONCRETE REFERENT MATERIAL)

	Graphic (16 items)			Slide Naming (6 items)			Slide Matching (6 items)		
	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population
Print/Silent/Linear	3.137	0.76	-1.20	2.599	0.63	- .53	11.408[a]	2.72	-1.05
Print/Silent/Branching	1.155	0.28	- .82	1.900	0.46	- .51	.179	0.04	- .15
Print/Redundant/Linear	8.454[a]	2.02	-1.94	9.578[a]	2.28	-1.01	10.534[a]	2.50	-1.01
Print/Redundant/Branching	8.564[a]	2.04	-2.22	2.289	0.56	- .56	1.277	0.31	- .40
Print/Directive/Linear	.438	0.16	- .47	.034	0.00	- .06	12.462[a]	2.96	-1.15
Print/Directive/Linear	1.622	0.39	- .90	.189	0.05	- .15	9.722[a]	2.31	- .02
Graphic/Silent/Linear	1.031	0.25	- .70	.053	0.01	- .08	.242	0.06	- .16
Graphic/Silent/Branching	2.423	0.59	+1.16	.497	0.12	+ .26	5.927[b]	1.44	+ .84
Graphic/Redundant/Linear	.000	0.00	.00	.011	0.00	- .04	.171	0.04	+ .13
Graphic/Redundant/Branching	.190	0.05	+ .31	.487	0.12	+ .24	1.306	0.32	+ .38
Graphic/Directive/Linear	1.930	0.47	+1.01	.015	0.00	+ .04	.917	0.22	+ .32
Graphic/Directive/Branching	1.436	0.35	+ .83	2.641	0.64	+ .55	6.260[b]	1.49	+ .80
Motion/Silent/Linear	.918	0.22	+ .67	1.568	0.38	+ .42	.024	0.00	+ .05
Motion/Silent/Branching	1.037	0.25	+ .71	1.568	0.38	+ .42	1.747	0.43	+ .43
Motion/Redundant/Linear	.665	0.16	+ .56	.662	0.16	+ .27	.122	0.03	+ .11
Motion/Redundant/Branching	3.029	0.73	+1.21	1.009	0.25	+ .34	10.906[a]	2.59	+1.05
Motion/Directive/Linear	1.159	0.28	+ .79	.015	0.00	+ .04	2.675	0.65	+ .55
Motion/Directive/Branching	2.232	0.54	+1.21	.871	0.21	+ .37	1.747	0.43	+ .49

[a] $p < .01$; [b] $p < .05$

TABLE 21 (continued)

	Motion-Picture (4 items)			Verbal (8 items)		
	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population
Print/Silent/Linear	.515	0.13	− .12	.049	0.01	+ .08
Print/Silent/Branching	.236	0.06	+ .10	.115	0.03	+ .14
Print/Redundant/Linear	.238	0.06	− .08	.295	0.07	+ .20
Print/Redundant/Branching	.287	0.06	− .10	.378	0.09	− .26
Print/Directive/Linear	.555	0.14	− .13	1.195	0.29	+ .33
Print/Directive/Branching	.045	0.01	+ .04	2.045	0.50	+ .56
Graphic/Silent/Linear	.246	0.06	− .09	1.856	0.45	− .52
Graphic/Silent/Branching	.224	0.05	+ .09	.413	0.10	− .26
Graphic/Redundant/Linear	.068	0.02	− .05	1.347	0.33	− .44
Graphic/Redundant/Branching	.554	0.14	− .13	.062	0.02	− .10
Graphic/Directive/Linear	.575	0.14	− .14	.448	0.11	− .27
Graphic/Directive/Branching	.068	0.02	− .05	.252	0.06	− .19
Motion/Silent/Linear	1.312	0.32	+ .20	.252	0.06	− .19
Motion/Silent/Branching	2.797	0.68	− .30	.494	0.12	+ .27
Motion/Redundant/Linear	6.340[b]	1.54	+ .44	.179	0.04	− .16
Motion/Redundant/Branching	2.615	0.64	+ .29	.660	0.16	+ .31
Motion/Directive/Linear	.001	0.00	.00	1.840	0.45	− .54
Motion/Directive/Branching	.060	0.01	+ .06	.310	0.08	− .25

[a] $p < .01$; [b] $p < .05$

were in accordance with the predictions of the stimulus generalization hypothesis, and the pattern confirmed that found in Experiment I.

CHAPTER VI

RESULTS: EXPERIMENT III

(ACTION-PROCESS REFERENT MATERIAL)

The results of Experiment III, relating to the use of materials consisting largely of presentations of actions and processes, are organized into three sections: description of the test results for the principal variables being studied, the analysis of these test results, and the results of the semantic differential rating of the teaching machine procedure employed. Later chapters will treat secondary variables as they relate to Experiment III.

A total of 433 subjects from Junior High Schools C and D participated in the experiment, 207 (47.8%) being boys and 226 (52.2%) being girls.

Description of Post-Test Results

Mean scores and standard deviations for the total performance post-test and for selected performance subtests are presented in Table 22. These data are presented for each treatment group and for the total population.

Examination of the total performance post-test scores for the eighteen treatment groups shows a range from 17.76 to 23.29 with a total mean of 21.07. The two Print/Directive treatments and the Graphic/Directive/Branching treatment were the most effective, and the Graphic and Motion/Redundant/Linear treatments were the least effective. On the seventeen verbal items of the post-test mean scores ranged from 6.92 to 9.81, on the eight graphic items from 3.84 to 4.75, and on the eight motion-picture items from 4.20 to 5.50.

TABLE 22

TOTAL POST-TEST AND SELECTED SUBTEST MEAN SCORES AND STANDARD DEVIATIONS FOR TREATMENT GROUPS AND TOTAL POPULATION (EXPERIMENT III: ACTION-PROCESS MATERIAL)

Tests / Treatment Groups	N	Total Score (37 items)		Verbal (17 items)		Graphic (8 items)		Motion-Picture (8 items)	
		$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	o	$\bar{X}$	σ
Print/Silent/Linear	24	22.42	5.65	9.13	3.19	4.63	1.35	5.38	1.44
Print/Silent/Branching	24	21.88	5.88	9.42	3.01	4.13	1.62	5.08	1.28
Print/Redundant/Linear	26	20.77	6.72	8.23	3.17	4.27	1.73	4.73	1.71
Print/Redundant/Branching	26	20.46	5.60	8.42	3.06	4.08	1.81	4.58	1.06
Print/Directive/Linear	25	22.88	6.98	9.44	3.57	4.32	1.89	5.40	1.41
Print/Directive/Branching	26	23.08	6.51	9.62	3.24	4.36	1.61	5.35	1.52
Graphic/Silent/Linear	25	19.92	6.54	7.80	2.92	4.52	1.61	4.84	1.55
Graphic/Silent/Branching	25	20.16	7.27	8.24	3.35	4.20	1.61	4.72	1.79
Graphic/Redundant/Linear	25	17.76	5.41	6.92	2.25	3.84	1.70	4.20	1.71
Graphic/Redundant/Branching	21	19.76	5.26	7.86	2.61	4.38	1.75	4.62	1.60
Graphic/Directive/Linear	22	20.68	6.37	7.82	3.96	4.45	1.65	5.50	1.65
Graphic/Directive/Branching	21	23.29	5.72	9.81	2.50	4.62	1.72	5.29	1.38
Motion/Silent/Linear	23	22.17	6.03	8.65	2.77	4.52	2.04	5.30	1.33
Motion/Silent/Branching	24	21.67	5.39	8.79	2.59	4.75	1.75	5.13	1.57
Motion/Redundant/Linear	25	18.76	7.03	7.12	2.92	4.20	2.04	4.56	2.08
Motion/Redundant/Branching	24	22.58	6.29	9.21	2.99	4.71	1.65	5.21	1.74
Motion/Directive/Linear	26	21.04	5.64	8.00	3.06	4.31	1.22	5.00	1.65
Motion/Directive/Branching	21	20.24	7.87	8.62	3.63	4.10	1.81	4.43	1.94
Total	433	21.07	6.32	8.50	3.19	4.37	1.69	4.96	1.65

Analysis of Post-Test Results

Test results were analyzed for total performance post-test scores using analysis of variance, analysis of covariance, and Scheffé's test for multiple comparisons; and for the verbal, graphic, and motion subtests separately, using the t-test and analysis of variance.

Selection of Covariates

Covariates for the analysis of covariance were selected by performing correlation and factor analyses of the test scores, using the three criteria described in Experiment I. The same covariates were selected as in Experiments I and II: total IQ and total F Battery scores.

An examination of Table 23 shows that total IQ had a high factor loading (.656) on Factor 4 and that total F Battery had a high loading (.889) on Factor 6. Table 61 in Appendix D shows these two covariates to have a .61 correlation with each other, which was moderate within the range of possible covariates to be considered. Sex and age were not considered as covariates because they correlated so low with the total performance post-test.

Correlation of Variables

The correlation of the post-test with the other variables followed the same general pattern as those in Experiments I and II. The post-test correlated highly with total IQ score (.68), the language IQ score (.71), and for all the achievement scores (.52 to .72). The part scores of the post-test correlated with total IQ in a range from .16 to .63 and with different parts of the California Achievement Test in a range from .56 to .78. The F Battery had a .53 correlation with total post-test. However, sex (.00 to .17) and age (.05 to .34) had low correlations with the total post-test and its subparts.

The total F Battery correlations with IQ and achievement scores were in the medium high range (.34 to .61), and its correlation with sex was low (.11). As might be expected, total IQ correlated highly with the achievement scores (.56 to .78).

TABLE 23

ROTATED FACTOR LOADING USED AS A BASIS FOR SELECTING COVARIATES APPLIED IN THE ANALYSIS OF COVARIANCE (N = 433) EXPERIMENT III: ACTION-PROCESS MATERIAL

Variables	Factors							
	1	2	3	4	5	6	7	8
Total Post-Test	-.309	-.005	-.108	.195	.816	.211	.160	-.327
Total F Battery	-.244	-.054	-.080	.257	.169	.889	.061	-.190
Sex	.057	.990	.020	.040	-.004	-.041	-.095	.033
Age	.137	.024	.942	-.165	-.082	-.071	-.119	.188
Language IQ	-.388	-.012	-.264	.249	.304	.156	.098	-.713
Non-Language IQ	-.264	.046	-.136	.903	.110	.208	.084	-.156
Total IQ	-.373	.020	-.232	.656	.240	.208	.106	-.500
Vocabulary	-.277	-.055	-.129	.165	.136	.161	.310	-.811
Verbal Comprehension	-.594	-.029	-.129	.221	.311	.110	.190	-.570
Arithmetic Reasoning	-.770	.014	-.102	.235	.245	.147	.132	-.374
Arithmetic Fundamentals	-.869	-.061	-.105	.248	.100	.167	.188	-.174
English Mechanics	.612	-.184	-.151	.171	.181	.267	.332	-.406
Spelling	-.359	-.163	-.169	.112	.158	.063	.800	-.337

Analysis of Total Post-Test Scores

Two analyses of variance were performed on these data, one with two covariates (total IQ and total F Battery) and one without. This schedule of analyses permitted estimates to be made of the effects of the covariates upon the unadjusted data. In addition, comparisons of individual variable performance test means were performed using Scheffé's test for multiple comparisons (1953, 1959). These tests permitted comparisons of selected variables and combinations of variables within the variance and covariance analyses. Table 24 presents the means for the interactions among all the variables, both unadjusted and adjusted, for the total performance post-test scores.

The results of the analyses of variance and covariance are presented in Tables 25 and 26. Neither of the analyses showed significant variations among the visual presentation modes, the programing modes, or the interactions of the three presentation modes. A significant difference was found only among the audio presentation modes ($p < .05$) in the analysis of variance. This significant difference was not confirmed in the analysis of covariance, however.

When multiple comparisons were made of the unadjusted mean scores, using the Scheffé test (1953, 1959), as shown in Table 27, the printed-verbal mode of presentation was significantly more effective than the still-graphic mode ($p < .01$), but it did not differ significantly from the motion-picture mode. However, there was a tendency for the printed-verbal mode to be more effective than both the still-graphic and motion-picture modes in both the analysis of variance and analysis of covariance comparisons. This finding was contrary to those in Experiments I and II.

The directive and silent sound modes were significantly superior to redundant sound at the .01 level. Directive sound maintained a superior level of effectiveness in the graphic/sound ($p < .05$ and $p < .01$) comparisons and also in the print/redundant and print/directive interactions ($p < .05$). Again, some indications of the superiority of the branching mode were obtained in the comparisons for graphic materials ($p < .10$) and in the redundant sound comparisons ($p < .05$). Inspections of the mean scores for the adjusted data indicated that multiple comparisons using the Scheffé test would provide little useful information and were

TABLE 24

TOTAL POST-TEST UNADJUSTED AND ADJUSTED MEAN SCORES (COVARIATES: TOTAL IQ AND TOTAL F BATTERY) EXPERIMENT III: ACTION-PROCESS MATERIAL

	N	Unadjusted	Adjusted
Visual Presentation Mode			
Printed Verbal	151	21.90	21.58
Still Graphic	139	20.18	20.77
Motion Picture	143	21.07	20.77
Audio Presentation Mode			
Silent	145	21.34	21.10
Redundant	147	20.01	20.78
Directive	141	21.90	21.28
Programing Mode			
Linear	221	20.69	20.86
Branching	212	21.47	21.26
Combined Modes			
Print/Silent/Linear	24	22.42	21.44
Print/Silent/Branching	24	21.88	20.49
Print/Redundant/Linear	26	20.77	21.67
Print/Redundant/Branching	26	20.46	21.09
Print/Directive/Linear	25	22.88	22.35
Print/Directive/Branching	26	23.08	22.27
Graphic/Silent/Linear	25	19.92	20.78
Graphic/Silent/Branching	25	20.16	21.10
Graphic/Redundant/Linear	25	17.76	20.31
Graphic/Redundant/Branching	21	19.76	19.80
Graphic/Directive/Linear	22	20.68	20.33
Graphic/Directive/Branching	21	23.29	22.27
Motion/Silent/Linear	23	22.17	21.43
Motion/Silent/Branching	24	21.67	21.33
Motion/Redundant/Linear	25	18.76	19.25
Motion/Redundant/Branching	24	22.58	22.51
Motion/Directive/Linear	26	21.04	20.16
Motion/Directive/Branching	21	20.24	19.99

TABLE 24 (continued)

	N	Unadjusted	Adjusted
Visual-Audio Modes			
Print/Silent	48	22.14	20.98
Print/Redundant	52	20.62	21.35
Print/Directive	51	22.98	22.39
Graphic/Silent	50	20.04	20.96
Graphic/Redundant	46	18.67	20.09
Graphic/Directive	43	21.96	21.28
Motion/Silent	47	21.92	21.38
Motion/Redundant	49	20.63	20.84
Motion/Directive	47	20.68	20.09
Visual-Programing Modes			
Print/Linear	75	22.00	21.81
Print/Branching	76	21.80	21.36
Graphic/Linear	72	19.40	20.49
Graphic/Branching	67	21.01	21.07
Motion/Linear	74	20.63	20.24
Motion/Branching	69	21.55	21.33
Audio-Programing Modes			
Silent/Linear	72	21.47	21.22
Silent/Branching	73	21.22	20.99
Redundant/Linear	76	19.12	20.41
Redundant/Branching	71	20.97	21.18
Directive/Linear	73	21.56	20.96
Directive/Branching	68	22.26	21.63
TOTAL	433	21.07	21.04

TABLE 25

TOTAL POST-TEST RESULTS (ANALYSIS OF VARIANCE) EXPERIMENT III: ACTION-PROCESS MATERIAL

Source of Variation	df	SS	MS	F	Prob.
Visual Modes (P:G:M)	2	196.851	98.426	2.500	<.10
Audio Modes (S:R:D)	2	264.082	132.041	3.354	<.05
Programing Modes (L:B)	1	59.828	59.828	1.520	-----
Visual (P:G:M) x Programing (L:B)	2	61.295	30.648	.779	-----
Audio (S:R:D) x Programing (L:B)	2	81.257	40.629	1.032	-----
Visual (P:G:M) x Audio (S:R:D)	4	171.509	42.877	1.089	-----
Visual (P:G:M) x Audio (S:R:D) x Programing (L:B)	4	119.869	29.967	.761	-----
Within	415	16336.475	39.365		

TABLE 26

TOTAL POST-TEST RESULTS (ANALYSIS OF COVARIANCE) (COVARIATES: TOTAL IQ AND TOTAL F BATTERY) EXPERIMENT III: ACTION-PROCESS MATERIAL

Source of Variation	df	SS	MS	F	Prob.
Visual Modes (P:G:M)	2	52.099	26.049	1.258	-----
Audio Modes (S:R:D)	2	22.429	11.215	.542	-----
Programing Modes (L:B)	1	18.777	18.777	.907	-----
Visual (P:G:M) x Programing (L:B)	2	57.949	28.975	1.400	-----
Audio (S:R:D) x Programing (L:B)	2	23.627	12.814	.570	-----
Visual (P:G:M) x Audio (S:R:D)	4	82.888	20.972	1.013	-----
Visual (P:G:M) x Audio (S:R:D) x Programing (L:B)	4	93.207	23.302	1.125	-----
Within	413	8552.428	20.708		

TABLE 27

COMPARISON OF INDIVIDUAL POST-TEST MEANS USING SCHEFFÉ'S TEST FOR MULTIPLE COMPARISONS (EXPERIMENT III: ACTION-PROCESS MATERIAL)

Comparisons	Unadjusted	
Still-Graphic vs. Printed-Verbal	20.18	21.90[a]
Redundant vs. Directive	20.01	21.90[a]
Redundant vs. Silent	20.01	21.34[a]
Print/Redundant vs. Print/Directive	20.62	22.98[b]
Graphic/Redundant vs. Graphic/Directive	18.67	21.96[a]
Graphic/Silent vs. Graphic/Directive	20.04	21.96[c]
Graphic/Linear vs. Graphic/Branching	19.40	21.01[c]
Redundant/Linear vs. Redundant/Branching	19.12	20.97[b]

[a]$p < .01$; [b]$p < .05$; [c]$p < .10$

not warranted.

Analysis of Selected Subtest Scores

Three of the six subtests in Experiment III were selected for separate analysis in order to determine the existence of any relationships between the mode of stimulus presentation and the mode of performance testing used. These three subtests (comprising 33 of the 37 items in the performance post-test) used test questions that could be described as verbal fill-in and multiple-choice (17 items), graphic fill-in and multiple-choice (8 items), and motion-picture multiple-choice (8 items). The verbal questions used words only; the graphic questions used graphic illustrative material as integral parts of the questions; and the motion-picture questions used projected film sequences as integral parts of the questions. Table 28 presents the unadjusted mean scores and standard deviations of the three subtests for the major variables under study.

TABLE 28

COMPARISON OF UNADJUSTED MEAN SCORES AND STANDARD DEVIATIONS FOR VERBAL, GRAPHIC, AND MOTION PICTURE PERFORMANCE SUBTESTS (EXPERIMENT III: ACTION-PROCESS MATERIAL)

	N	Verbal Items (17)		Graphic Items (8)		Motion-Picture Items (8)	
		$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Visual Presentation Mode							
Printed-Verbal	151	9.04	3.27	4.36	1.57	5.08	1.47
Still-Graphic	139	8.05	3.15	4.33	1.70	4.87	1.68
Motion-Picture	143	8.36	3.08	4.42	1.79	4.92	1.79
Audio Presentation Mode							
Silent	145	8.66	3.04	4.51	1.54	5.07	1.52
Redundant	147	7.94	2.98	4.23	1.83	4.64	1.71
Directive	141	8.86	3.49	4.37	1.67	5.16	1.65
Programing Mode							
Linear	221	8.13	3.24	4.37	1.67	5.00	1.67
Branching	212	8.88	3.11	4.37	1.72	4.92	1.62
TOTAL	433	8.50	3.19	4.37	1.69	4.96	1.65

Only the seventeen verbal subtest items showed support for the stimulus generalization hypothesis that learning of presented information increases as the testing situation becomes more similar to the presentation situation. On the verbal subtest the subjects exposed to the printed-verbal presentation mode performed better than did those exposed to either the still-graphic or motion-picture presentation modes, this superiority being statistically significant only for the printed-verbal/still-graphic comparison ($p < .01$).

Two other interactions were also found to be statistically significant on the verbal subtest items. The directive audio presentation mode was superior to the redundant audio mode at the .05 level, and the branching programing mode was superior to the linear mode at the .05 level.

In a further analysis of variance for all eighteen experimental treatments, as shown in Table 29, no consistent pattern of relationships between mode of presentation and nature of the post-test items was found. Of the four statistically significant differences, three were in the predicted direction and one was in the opposite direction. However, only very slight support for the stimulus generalization hypothesis could be found from the analysis of these data.

Attitude Toward Concept "Teaching Machine"

The semantic differential instrument, consisting of eleven 7-point scales representing the Evaluative, Activity, and Potency divisions, was administered to 428 subjects in Experiment III. The concept, "Teaching Machines," was rated on each of the scales as described in Chapter III. The results of this analysis for factor scores by groups and for distance between groups are presented in Table 30.

The mean factor scores were derived from a 7-point scale, with the higher scores reflecting positive values and the lower scores negative values. The score of 4 reflects a neutral value at the midpoint of the scale. It will be noted that all mean factor scores fell to the positive side of the scale, with the Evaluative dimension showing the highest positive value, the Activity dimension the next highest, and the Potency dimension with virtually a neutral value. However, none of the comparisons among groups

TABLE 29

COMPARISON OF F VALUES, PERCENT OF VARIATION ATTRIBUTABLE TO TEST ITEM TYPE, AND RELATIONSHIP TO MEAN SCORE IN TOTAL POPULATION FOR SELECTED PERFORMANCE SUBTESTS (ANALYSIS OF VARIANCE) (EXPERIMENT III: ACTION-PROCESS MATERIAL)

	Verbal (17 items)			Graphic (8 items)			Motion-Picture (8 items)		
	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population	F Value	Percent of Variation	Relation to Mean Score in Total Population
Print/Silent/Linear	1.033	0.24	+ .63	.645	0.15	+.27	1.708	0.40	+.42
Print/Silent/Branching	2.220	0.05	+ .92	.473	0.11	-.23	.153	0.04	+.12
Print/Redundant/Linear	.201	0.04	- .27	.072	0.02	-.09	.554	0.12	-.23
Print/Redundant/Branching	.015	0.04	- .07	.742	0.16	-.28	1.559	0.36	-.38
Print/Directive/Linear	2.438	0.56	+ .94	.012	0.03	-.04	2.005	0.46	+.44
Print/Directive/Branching	3.584	0.81	+1.12	.108	0.03	+.09	1.610	0.36	+.39
Graphic/Silent/Linear	1.326	0.30	- .79	.251	0.06	+.16	.144	0.03	-.12
Graphic/Silent/Branching	.179	0.04	- .26	.225	0.05	-.16	.583	0.14	-.24
Graphic/Redundant/Linear	6.878[a]	1.56	-1.58	2.480	0.58	-.52	5.969[b]	1.37	-.76
Graphic/Redundant/Branching	.928	0.21	- .64	.005	0.00	+.02	.983	0.23	-.34
Graphic/Directive/Linear	1.098	0.25	- .68	.079	0.02	+.10	2.638	0.61	+.54
Graphic/Directive/Branching	3.942[b]	0.90	+1.31	.536	0.12	+.26	.914	0.21	+.33
Motion/Silent/Linear	.060	0.01	+ .16	.234	0.05	+.17	1.124	0.03	+.35
Motion/Silent/Branching	.227	0.05	+ .30	1.385	0.32	+.39	.272	0.06	+.17
Motion/Redundant/Linear	5.224[b]	1.21	-1.38	.225	0.05	-.16	1.631	0.04	-.40
Motion/Redundant/Branching	1.326	0.30	+ .71	1.107	0.26	+.35	.613	0.14	+.25
Motion/Directive/Linear	.701	0.02	- .50	.022	0.05	-.05	.018	0.04	+.04
Motion/Directive/Branching	.034	0.01	+ .12	.524	0.12	-.26	2.404	0.55	-.53

[a] $p < .01$; [b] $p < .05$

TABLE 30

MEAN FACTOR SCORES AND DISTANCES FOR COMBINED TREATMENT GROUPS (EXPERIMENT III: ACTION-PROCESS MATERIAL)

	N	Mean Factor Scores			Distances			
		Evaluative	Activity	Potency				
Visual Presentation						P-V	S-G	M-P
Printed-Verbal	147	5.2571	4.2363	4.1890	P-V	0	.3295	.2315
Still-Graphic	135	5.2800	4.5424	4.3087	S-G	.3295	0	.2338
Motion-Picture	146	5.3000	4.4445	4.0973	M-P	.2315	.2338	0
Audio Presentation						Sil	Red	Dir
Silent	141	5.1489	4.5026	4.2486	Sil	0	.2821	.3981
Redundant	144	5.4141	4.5717	4.1817	Red	.2821	0	.4599
Directive	143	5.2713	4.1353	4.1557	Dir	.3981	.4599	0
Programing Approach						Lin	Br	
Linear	219	5.2379	4.4173	4.2970	Lin	0	.2270	
Branching	209	5.3222	4.3883	4.0882	Br	.2270	0	

for any of the dimensions were statistically significant.

An examination of the values in the distance matrices (indicating the greatest differences between groups on all dimensions) reveals that the largest distance for the visual presentation mode was .3295 between the Printed-Verbal and Still-Graphic groups. Examining the three dimension values for these two groups we see:

	Evaluative	Activity	Potency
Still-Graphic	5.2800	4.5424	4.3087
Printed-Verbal	5.2571	4.2363	4.1890
Difference	.0229	.3061	.1197

Here, it appears that the Activity dimension contributed the most to the distance and the Evaluative dimension the least. For the audio presentation mode the largest difference was .4599 between the Redundant and Directive groups. Examining the three dimension values for these two groups we see:

	Evaluative	Activity	Potency
Redundant	5.4141	4.5717	4.1817
Directive	5.2713	4.1353	4.1557
Difference	.1428	.4364	.0260

In this case, also, the Activity dimension contributed the most to the distance. For the programing approach the difference was only .2270 between the Linear and Branching groups. In this case, the Potency dimension contributed the most to the difference. In the seven comparisons among groups, the Activity dimension contributed the most to the distances in four cases, the Potency dimension in two cases, and the Evaluative dimension in one case.

It would appear, therefore, that although no significant differences occurred among the comparisons made, there was a tendency for the Activity dimension to contribute the most to the distances among the various treatment groups and for the Evaluative dimension to show the highest positive value for all the treatment groups. It might be concluded that this group of subjects found the Still-Graphic, Motion-Picture, and Redundant Sound treatments more active (*i.e.*, fast, varied, loud, and active), and that the teaching machines as such were evaluated as fairly good, pleasant, kind, and a play-type experience.

CHAPTER VII

RESULTS: LEARNER CHARACTERISTICS[1]

The results of the analyses of the relationships between post-test performance and each of the different learner characteristics studied are presented in this chapter for all three experiments combined. The specific learner characteristics considered are IQ score, ethnic grouping, occupation of parent, sex, and score on the F Battery.

IQ Score

Determination of how the High IQ students ($IQ \geqq 101$) and the Low IQ students ($IQ \leqq 100$) performed on the post-tests in relation to the experimental treatment received was accomplished through separate analyses of variance reported in Table 31 for each of the three experiments. Post-test performance in Experiments I and III showed no significant differences when examined for all 18 treatments separately for each IQ group. However, in Experiment II only the High IQ group ($p < .05$) reflected a meaningful difference.

The total mean scores and standard deviations for the performance post-test, tabulated for each IQ group, are presented in Table 32. There appeared to be no consistent pattern of performance among the 18 treatments related to high or low IQ.

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[1] The results of this analysis are reported in greater detail by means of multiple regression analysis in a doctoral dissertation by Filep (1966).

TABLE 31

HIGH (≧ 101) AND LOW (≦ 100) IQ GROUPS FOR THE 18 EXPERIMENTAL TREATMENTS (ANALYSIS OF VARIANCE)

	Source	df	SS	MS	F	p
Experiment I						
High IQ	Between	17	1023.28	60.19	1.186	-----
	Within	168	8526.69	50.75		
	Total	185	9549.96			
Low IQ	Between	17	469.72	27.68	.736	-----
	Within	183	6871.16	37.55		
	Total	200	7340.88			
Experiment II						
High IQ	Between	17	1230.79	72.40	1.889	<0.05
	Within	217	8314.98	38.32		
	Total	234	9545.76			
Low IQ	Between	17	1972.16	116.01	1.628	-----
	Within	158	11258.02	71.25		
	Total	175	13230.18			
Experiment III						
High IQ	Between	17	515.61	30.33	1.069	-----
	Within	222	6299.58	28.38		
	Total	239	6815.18			
Low IQ	Between	17	404.56	23.80	.858	-----
	Within	160	4439.44	27.75		
	Total	177	4844.00			

TABLE 32

TOTAL POST-TEST MEAN SCORES AND STANDARD DEVIATIONS FOR TREATMENT GROUPS AND HIGH (≧ 101) AND LOW (≦ 100) IQ GROUPS

	Experiment I				Experiment II				Experiment III			
	High IQ		Low IQ		High IQ		Low IQ		High IQ		Low IQ	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Print/Silent/Linear	25.58	6.60	17.57	8.18	34.23	6.38	22.33	8.27	24.50	3.27	18.25	7.23
Print/Silent/Branching	26.50	8.26	17.86	3.84	32.75	5.85	21.25	12.07	24.06	4.91	17.50	5.40
Print/Redundant/Linear	24.57	7.91	15.54	3.23	32.25	4.60	22.62	5.99	23.75	5.61	18.21	6.72
Print/Redundant/Branching	28.36	7.42	18.67	8.34	33.33	7.81	18.38	6.55	22.93	4.78	17.58	5.25
Print/Directive/Linear	26.21	6.08	18.00	6.91	34.53	4.34	24.13	12.65	27.20	4.90	16.40	3.86
Print/Directive/Branching	24.00	6.25	18.88	5.03	36.08	5.85	24.70	4.92	25.72	5.05	17.13	5.57
Graphic/Silent/Linear	26.27	6.70	15.18	4.49	35.60	6.51	21.67	9.37	24.20	6.13	17.07	5.24
Graphic/Silent/Branching	31.40	7.64	18.40	4.21	39.25	3.96	28.56	8.37	23.73	6.22	14.80	5.27
Graphic/Redundant/Linear	26.50	2.59	19.33	6.67	36.62	7.76	25.27	7.43	22.22	4.89	15.25	3.92
Graphic/Redundant/Branching	28.14	9.12	19.14	6.09	37.75	6.31	26.91	8.41	22.18	5.38	17.10	3.78
Graphic/Directive/Linear	29.58	5.45	16.89	3.89	36.77	6.25	26.78	6.20	23.15	5.58	17.11	5.97
Graphic/Directive/Branching	29.67	6.31	18.82	8.17	37.50	6.01	31.50	8.46	25.23	5.29	20.13	5.19
Motion/Silent/Linear	28.85	8.42	16.80	6.27	36.50	8.11	28.78	8.35	23.75	5.52	18.57	5.94
Motion/Silent/Branching	25.89	7.90	20.10	6.82	37.79	8.48	26.90	9.84	24.00	3.96	18.40	5.60
Motion/Redundant/Linear	22.15	6.11	21.70	8.77	40.54	3.82	25.75	9.29	22.54	5.85	14.67	5.94
Motion/Redundant/Branching	28.40	7.25	19.83	5.78	39.93	4.52	31.00	10.31	25.43	6.45	18.60	3.31
Motion/Directive/Linear	23.08	8.77	18.50	5.93	37.50	5.16	27.70	6.52	23.00	5.61	17.33	3.57
Motion/Directive/Branching	25.60	8.91	19.17	5.20	37.50	6.38	24.50	9.14	26.10	6.47	14.91	4.55
Total	26.45	7.18	18.28	6.05	36.39	6.39	25.82	8.69	24.15	5.32	17.02	5.17

In order to determine the differential relationships of IQ to the three major presentation variables studied, mean post-test scores were compared by analysis of variance. Table 33 presents the data for the two IQ groups with the three visual presentation modes. There were no significant differences in performance in Experiments I and III. However, in Experiment II, both the High and Low IQ groups showed highly significant differences ($p < .001$ and $p < .01$), performance on the two pictorial presentation modes being superior to that on the printed-verbal mode. These results were consistent with the findings in other phases of the study and revealed no relationships between IQ level and type of visual presentation mode employed.

The interactions of the two IQ groups with the three audio presentation modes are shown in Table 34 and with the two programing approaches in Table 35. No significant differences for any of the comparisons were found.

It would appear, from a study of all the results for the High and Low IQ groups, that the subjects' mental ability level showed little or no relationship to the learning of content having different kinds of visual, audio, programing, or content inherency characteristics.

Ethnic Grouping

The post-test performance scores for the subjects in the three experiments were analyzed under four ethnic classifications: Negro, Oriental-American, Mexican-American, and Caucasian. The post-test means and standard deviations for these four groups are given separately for males and females in Tables 36 and 37. The analyses of variance showed significant values of F for ethnic classifications stratified by sex. Four comparisons were significant at the .01 level and two others at the .05 level.

Difficulties were encountered when an examination of ethnic differences in any one experiment was attempted. In many instances a particular treatment had not been viewed by any sizeable number of Oriental-American or Mexican-American students. The total n's for the ethnic classifications reflected these shortages, particularly for Experiment I. However, the distributions in this study were comparable to those reported for the school district and the state (California

TABLE 33

COMPARISON OF POST-TEST MEANS FOR HIGH AND LOW IQ GROUPS FOR VISUAL PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Printed-Verbal			Still-Graphic			Motion-Picture			df	F	p
	N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ			
Experiment I												
High IQ	64	25.83	6.75	54	28.33	6.23	68	25.53		2/183	2.702	-----
Low IQ	68	17.60	6.02	69	18.03	5.71	64	19.36	6.40	2/198	1.505	-----
Experiment II												
High IQ	81	33.86	5.82	75	37.16	6.17	79	38.24	6.39	2/232	11.072	$<.001$
Low IQ	55	22.44	8.02	63	27.11	8.38	58	27.62	8.87	2/173	6.486	$< .01$
Experiment III												
High IQ	91	24.77	4.84	65	23.43	5.62	84	24.01	5.61	2/237	1.232	-----
Low IQ	60	17.55	5.58	59	16.56	5.11	59	16.88	5.03	2/175	.553	-----

TABLE 34

COMPARISON OF POST-TEST MEANS FOR HIGH AND LOW IQ GROUPS FOR AUDIO PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Silent			Redundant			Directive			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
High IQ	56	27.14	7.43	54	26.43	6.94	64	25.48	7.25	2/171	.800	-----
Low IQ	74	17.68	5.77	60	19.07	6.22	58	18.64	5.85	2/189	.976	
Experiment II												
High IQ	85	35.87	6.91	63	37.49	6.16	75	36.53	5.58	2/220	1.209	-----
Low IQ	53	25.15	9.20	58	26.17	8.52	57	27.12	8.26	2/165	.713	-----
Experiment III												
High IQ	87	24.03	4.90	53	23.21	5.80	82	25.23	5.51	2/219	2.452	-----
Low IQ	58	17.31	5.61	53	16.51	5.30	52	16.87	4.65	2/160	.329	-----

TABLE 35

COMPARISON OF POST-TEST MEANS FOR HIGH AND LOW IQ GROUPS FOR PROGRAMING PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Linear			Branching			df	F	p
	N	$\bar{x}$	σ	N	$\bar{x}$	σ			
Experiment I									
High IQ	97	25.44	6.89	81	27.17	7.50	1/176	2.566	-----
Low IQ	94	17.73	6.33	105	18.94	5.76	1/197	1.988	-----
Experiment II									
High IQ	121	36.04	6.27	114	36.75	6.52	1/233	.731	-----
Low IQ	93	24.88	8.25	83	26.87	9.11	1/174	2.305	-----
Experiment III									
High IQ	117	24.01	5.32	119	24.39	5.40	1/234	.293	-----
Low IQ	97	16.72	5.30	78	17.24	5.07	1/173	.436	-----

TABLE 36

TOTAL POST-TEST MEAN SCORES AND STANDARD DEVIATIONS FOR MALES IN ETHNIC GROUPS (ANALYSIS OF VARIANCE)

Ethnic Group	Code	Experiment I			Experiment II			Experiment III		
		N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ
Negro	(1)	91	20.04	6.68	39	23.43	11.00	11	19.63	7.73
Oriental-American	(2)	3	18.33	7.09	17	34.58	8.65	18	20.50	6.75
Mexican-American	(3)	7	18.14	7.10	16	27.56	8.35	44	17.93	5.86
Caucasian	(4)	94	25.01	8.25	119	33.19	7.83	134	21.75	6.37
Total		195	22.34	7.86	191	30.85	9.54	207	20.71	6.52

Analysis of Variance	df	F	p	df	F	p	df	F	p
	3/191	7.80	$<.01$	3/187	14.18	$<.01$	3/203	4.08	$<.05$

TABLE 37

TOTAL POST-TEST MEAN SCORES AND STANDARD DEVIATIONS FOR FEMALES IN ETHNIC GROUPS (ANALYSIS OF VARIANCE)

Ethnic Group	Code	Experiment I			Experiment II			Experiment III		
		N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ
Negro	(1)	91	20.51	6.84	61	27.90	8.35	12	20.50	6.76
Oriental-American	(2)	2	25.50	3.53	17	34.88	7.30	31	24.93	6.08
Mexican-American	(3)	7	19.28	11.05	15	34.86	7.66	41	17.19	5.28
Caucasian	(4)	93	23.67	7.91	127	34.51	8.22	142	21.96	5.71
Total		193	22.04	7.66	220	32.76	8.64	226	21.39	6.14

Analysis of Variance	df	F	p	df	F	p	df	F	p
	3/189	3.15	<.05	3/216	9.89	<.01	3/222	11.70	<.01

School Boards Association, 1965).

In order to facilitate comparisons of ethnic groups between and across experimental treatments some grouping of categories was required. The pattern of post-test performance seemed to indicate that the means and standard deviations for the Negro and Mexican-American students were similar enough to justify placing their data in a designated "Non-White" category. The post-test scores for the Oriental-American students generally paralleled those recorded for the Caucasian students. A decision was then made to omit the Oriental students from the measure in order to provide a sharper contrast, and thus creating a group to include the Caucasian students designated "White," and also to avoid further exaggerating the difference in number between the White and Non-White groups. This decision reduced the sample size in Experiment I by 1.3 percent; in Experiment II by 8.4 percent; and in Experiment III by 11.3 percent.

Determination of how the White and Non-White students performed on the post-tests in relation to the experimental treatment received was accomplished through separate analyses of variance as reported in Table 38 for each of the experiments. None of the groups for any of the experiments showed statistically significant differences.

The total mean scores and standard deviations for the performance post-test, tabulated for each ethnic group, are presented in Table 39. There appeared to be no consistent pattern of performance among the 18 treatments related to White or Non-White ethnic grouping.

In order to determine the differential relationships of ethnic background to the three major presentation variables studied, mean post-test scores for the White and Non-White groups were compared by analysis of variance and t-test. Table 40 presents the data for the two ethnic groups as they interacted with the three visual presentation modes. In Experiments I and III the same patterns of performance held for both the White and Non-White groups. The performance of the two groups differed slightly in Experiment II, however, the White group performing best with the motion-picture treatment (significantly superior to both other groups) and the Non-White performing best on the still-graphic version (significantly superior only to the printed-verbal group).

TABLE 38

WHITE AND NON-WHITE ETHNIC GROUPS FOR THE 18 EXPERIMENTAL TREATMENTS (ANALYSIS OF VARIANCE)

	Source	df	SS	MS	F	P
Experiment I						
White	Between	17	1676.45	98.61	1.584	-----
	Within	169	10521.95	62.26		
	Total	186	12198.41			
Non-White	Between	17	931.95	54.82	1.163	-----
	Within	178	8391.50	47.14		
	Total	195	9323.44			
Experiment II						
White	Between	17	1960.47	115.32	1.891	-----
	Within	228	13907.86	61.00		
	Total	245	15868.34			
Non-White	Between	17	1730.64	101.80	1.107	-----
	Within	113	10392.25	91.87		
	Total	130	12122.89			
Experiment III						
White	Between	17	847.59	49.86	1.404	-----
	Within	258	9162.07	35.51		
	Total	275	10009.66			
Non-White	Between	17	1010.34	59.43	1.898	-----
	Within	90	2818.32	31.31		
	Total	107	3828.67			

TABLE 39

TOTAL POST-TEST MEAN SCORES AND STANDARD DEVIATIONS FOR TREATMENT GROUPS AND FOR WHITE AND NON-WHITE ETHNIC GROUPS (EXPERIMENTS I, II, AND III)

	Experiment I				Experiment II				Experiment III			
	White		Non-White		White		Non-White		White		Non-White	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Print/Silent/Linear	21.80	8.10	20.55	9.14	32.67	7.98	24.36	10.07	23.94	4.43	17.83	6.82
Print/Silent/Branching	21.73	8.21	18.30	4.27	31.89	6.36	5.00	0.00	21.17	5.86	21.13	6.03
Print/Redundant/Linear	19.55	8.03	16.38	3.58	27.93	6.27	22.71	7.87	20.35	6.23	24.50	5.26
Print/Redundant/Branching	29.63	6.76	20.25	8.69	27.67	9.54	24.43	10.85	21.79	4.48	17.89	6.86
Print/Directive/Linear	27.00	6.58	18.58	6.05	33.15	6.14	27.44	12.66	25.63	5.81	16.38	4.47
Print/Directive/Branching	22.00	6.58	22.25	6.24	32.71	7.33	24.00	5.76	24.00	7.27	21.00	4.43
Graphic/Silent/Linear	25.25	7.22	15.30	4.85	33.20	8.72	24.88	11.70	20.33	5.88	16.50	6.25
Graphic/Silent/Branching	20.50	8.96	22.80	6.37	35.17	7.67	32.75	8.89	22.20	6.72	17.14	7.01
Graphic/Redundant/Linear	23.60	6.79	24.00	4.36	33.57	8.36	24.71	9.62	19.06	5.93	15.14	4.02
Graphic/Redundant/Branching	26.25	10.42	19.62	5.64	34.92	9.08	29.33	9.10	20.07	4.62	14.67	2.08
Graphic/Directive/Linear	29.33	7.35	20.25	6.18	33.86	8.62	29.86	6.52	22.71	5.06	12.00	1.41
Graphic/Directive/Branching	24.82	9.66	22.33	8.69	35.92	7.79	32.50	7.43	23.73	6.15	21.50	4.80
Motion/Silent/Linear	29.64	7.51	18.08	7.94	36.50	8.28	27.13	7.68	20.93	6.48	23.33	3.79
Motion/Silent/Branching	24.20	7.63	22.50	8.47	35.14	9.12	27.50	11.20	22.71	4.39	17.00	4.80
Motion/Redundant/Linear	22.82	7.39	21.17	7.26	35.81	9.24	26.00	10.05	19.44	6.97	16.38	6.95
Motion/Redundant/Branching	26.58	6.40	20.30	7.99	40.00	4.86	29.80	10.02	21.69	6.36	22.67	6.38
Motion/Directive/Linear	24.27	9.13	18.17	5.31	34.21	5.95	33.00	10.39	21.00	5.51	17.00	0.00
Motion/Directive/Branching	21.60	8.40	22.50	7.38	37.73	7.24	27.40	7.89	22.91	8.29	14.71	4.68
Total	24.35	8.10	20.17	6.91	33.88	8.05	27.33	9.66	21.84	6.03	18.11	5.98

TABLE 40

COMPARISONS OF POST-TEST MEANS FOR WHITE AND NON-WHITE ETHNIC GROUPS FOR VISUAL PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Printed-Verbal			Still-Graphic			Motion-Picture			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
White	67	23.31	7.92	60	24.85	8.48	60	25.00	7.93	2/184	.855	-----
Non-White	65	19.58	6.80	61	20.46	6.52	70	20.46	7.40	2/193	.344	-----
Experiment II												
White	85	31.05	7.36	81	34.38	8.20	80	36.38	7.74	2/243	9.946	.001
Non-White	41	24.24	10.02	47	29.09	9.15	43	28.35	9.35	2/128	3.215	.05
Experiment III												
White	93	22.90	5.93	93	21.28	5.86	90	21.31	6.24	2/273	2.210	-----
Non-White	41	19.32	5.99	31	16.23	5.40	36	18.36	6.20	2/105	2.470	-----

The interactions of the two ethnic groups with the three audio presentation modes are shown in Table 41. The only significant difference was with the White group in Experiment III, wherein the directive sound mode was superior to the other two modes ($p < .01$). In that experiment, the directive mode was least effective with the Non-White group.

The interactions of the two ethnic groups with the two programing approaches are shown in Table 42. In all three experiments, the Non-White groups appeared to profit more from the branching mode of presentation than did the White group. In each case, the Non-White groups showed a small (significant at .01 level only in Experiment I) superiority on the branching treatments.

Occupation of Parents

The post-test performance scores for the subjects in the three experiments were analyzed under six categories of the parents' occupation: professional, managerial, clerical, skilled, semi-skilled, and unskilled. The post-test means and standard deviations for the occupational groups as they interacted with the three major presentation variables are presented in Tables 43, 44, and 45. The analyses of variance showed significant values of F for all three experiments. However, there appeared to be no discernible pattern of performance for any of the occupational groups singly or in combination. That is, none of the groups consistently performed at a higher level under specific stimulus conditions. The only differences that might have occurred favored the lower occupation students under the branching stimulus conditions, and this advantage was very slight.

Sex

Determination of how the two sex groups performed on the post-tests in relation to the experimental treatment received was accomplished through separate analyses of variance reported in Table 46 for each of the three experiments. None of the groups for any of the experiments showed statistically significant differences.

The total mean scores and standard deviations for the performance post-test, tabulated for each sex group, are

TABLE 41

COMPARISON OF POST-TEST MEANS FOR WHITE AND NON-WHITE ETHNIC GROUPS FOR AUDIO PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Silent			Redundant			Directive			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
White	64	23.77	8.26	60	24.47	7.95	63	24.83	8.16	2/184	.279	-----
Non-White	65	19.65	7.40	62	20.23	6.78	69	20.61	6.63	2/193	.325	-----
Experiment II												
White	85	33.99	7.95	81	33.19	8.95	80	34.46	7.19	2/243	.517	-----
Non-White	44	26.61	10.43	47	26.53	9.49	40	29.05	8.97	2/128	.914	-----
Experiment III												
White	92	21.91	5.66	91	20.33	5.80	93	23.24	6.31	2/273	5.526	$< .01$
Non-White	37	18.49	6.07	40	18.60	6.59	31	17.03	5.04	2/105	.707	-----

TABLE 42

COMPARISON OF POST-TEST MEANS FOR WHITE AND NON-WHITE ETHNIC GROUPS FOR PROGRAMING MODES (ANALYSIS OF VARIANCE)

	Linear			Branching			df	F	P
	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I									
White	102	24.64	7.96	85	24.00	8.29	1/185	.286	-----
Non-White	96	19.09	6.60	100	21.20	7.08	1/194	4.269	$<$ .05
Experiment II									
White	128	33.44	7.94	118	34.36	8.17	1/244	.799	-----
Non-White	69	26.36	9.69	62	28.40	9.58	1/129	1.464	-----
Experiment III									
White	151	21.47	6.04	125	22.28	6.02	1/274	1.233	-----
Non-White	48	17.17	5.84	60	18.87	6.04	1/106	2.178	-----

TABLE 43

COMPARISON OF POST-TEST MEANS BY OCCUPATIONAL GROUPS FOR VISUAL PRESENTATION MODES

	Printed-Verbal			Still-Graphic			Motion-Picture		
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ
Experiment I									
Professional	28	24.32	7.08	23	28.13	7.88	34	24.47	7.94
Managerial	17	24.94	7.74	15	21.33	7.24	8	22.50	8.32
Clerical	15	19.13	5.48	17	21.59	7.62	23	26.96	7.91
Skilled	29	20.97	9.22	18	19.67	6.52	28	20.29	6.86
Semi-skilled	8	23.75	7.99	19	20.74	6.93	14	21.43	7.80
Unskilled	31	18.42	5.74	22	21.45	6.99	12	20.67	7.19
No Designation	5	20.40	7.09	9	24.44	10.11	13	17.46	6.55
Analysis of Variance:	20/367 df			F = 2.791			$p < .01$		
Experiment II									
Professional	22	31.50	6.47	23	37.50	5.80	36	38.94	5.81
Managerial	26	34.88	6.38	26	34.15	7.44	24	34.67	9.25
Clerical	27	31.41	8.67	22	31.77	8.70	16	32.88	8.83
Skilled	26	27.00	7.68	37	31.86	10.17	36	32.17	8.93
Semi-skilled	17	23.94	8.48	13	25.00	9.00	9	28.89	10.45
Unskilled	11	21.91	8.76	12	32.08	7.28	12	26.42	10.22
No Designation	7	25.57	11.91	5	30.40	6.46	4	32.00	10.71
Analysis of Variance:	20/390 df			F = 5.316			$p < .01$		
Experiment III									
Professional	34	24.59	5.26	34	23.50	6.32	29	24.59	5.65
Managerial	31	22.13	5.63	19	20.16	5.63	21	22.76	5.33
Clerical	21	22.48	7.67	15	21.60	6.02	21	19.90	8.51
Skilled	37	20.78	6.36	41	18.20	5.09	31	20.90	5.83
Semi-skilled	19	18.37	5.67	23	17.87	6.98	30	19.23	4.99
Unskilled	1	13.00	0.00	2	24.00	5.66	4	12.25	4.99
No Designation	8	22.75	4.27	5	18.80	6.30	7	18.57	5.88
Analysis of Variance:	20/412 df			F = 3.428			$p < .001$		

TABLE 44

COMPARISON OF POST-TEST MEANS BY OCCUPATIONAL GROUPS FOR AUDIO PRESENTATION MODES

	Silent			Redundant			Directive		
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ
Experiment I									
Professional	26	25.04	8.03	28	24.14	7.28	31	26.87	7.90
Managerial	11	20.55	7.93	10	22.70	7.75	19	24.79	7.41
Clerical	26	23.12	7.63	15	24.40	8.51	14	21.93	7.99
Skilled	28	19.32	8.10	24	21.33	8.45	23	20.74	6.47
Semi-skilled	7	23.43	9.07	21	22.00	6.38	13	19.85	8.06
Unskilled	28	20.14	6.86	18	18.11	4.75	19	21.11	7.34
No Designation	5	18.80	11.37	9	24.00	10.42	13	18.38	4.35
Analysis of Variance:		20/367 df			F = 2.049				$p < .05$
Experiment II									
Professional	26	37.19	6.40	28	36.14	7.14	27	36.41	6.74
Managerial	29	35.21	7.94	25	34.36	7.33	22	33.95	7.88
Clerical	18	31.22	8.35	23	30.87	10.02	24	33.38	7.39
Skilled	36	30.03	9.05	32	31.03	11.09	31	31.13	7.68
Semi-skilled	11	23.91	9.26	18	25.61	8.71	10	26.80	10.29
Unskilled	11	25.18	12.52	12	25.33	7.55	12	30.17	8.07
No Designation	7	30.14	9.08	3	29.33	11.59	6	26.67	11.71
Analysis of Variance:		20/390 df			F = 3.782				$p < .001$
Experiment III									
Professional	31	23.61	5.23	26	23.15	5.65	40	25.35	6.07
Managerial	31	22.81	5.17	22	19.73	5.07	18	22.56	6.35
Clerical	16	24.25	7.15	26	19.81	7.91	15	20.73	6.93
Skilled	35	19.17	6.11	39	19.15	5.65	35	21.29	5.70
Semi-skilled	25	18.52	5.80	22	18.77	5.70	25	18.44	6.14
Unskilled	2	20.50	10.61	4	14.50	6.14	1	11.00	0.00
No Designation	5	18.60	4.72	8	21.63	5.85	7	20.00	6.00
Analysis of Variance:		20/412 df			F = 3.417				$p < .001$

TABLE 45

COMPARISON OF POST-TEST MEANS BY OCCUPATIONAL GROUPS FOR PROGRAMING MODES

	Linear			Branching		
	N	$\bar{x}$	σ	N	$\bar{x}$	σ
Experiment I						
Professional	50	24.88	7.91	35	26.17	7.54
Managerial	18	23.67	7.28	22	22.64	8.09
Clerical	32	22.38	7.93	23	24.26	7.82
Skilled	34	19.88	7.97	41	20.83	7.54
Semi-skilled	20	22.80	7.24	21	20.38	7.41
Unskilled	33	18.76	6.08	32	21.00	6.83
No Designation	14	19.43	8.52	13	21.31	8.30
Analysis of Variance:	13/374 df			F = 2.610		$p < .05$
Experiment II						
Professional	46	35.83	6.42	35	37.54	7.03
Managerial	37	34.35	7.54	39	34.77	7.83
Clerical	35	32.40	7.92	30	31.30	9.44
Skilled	49	28.61	9.53	50	32.74	8.68
Semi-skilled	17	24.24	8.78	22	26.36	9.43
Unskilled	21	26.90	9.78	14	27.00	9.56
No Designation	9	27.00	10.49	7	30.86	9.58
Analysis of Variance:	13/397 df			F = 6.157		$p < .001$
Experiment III						
Professional	49	24.29	6.04	48	24.13	5.46
Managerial	41	21.98	4.81	30	21.53	6.52
Clerical	31	19.71	7.63	26	23.19	7.18
Skilled	53	19.68	6.28	56	20.00	5.46
Semi-skilled	36	17.72	4.84	36	19.42	6.60
Unskilled	4	15.00	9.06	3	16.67	4.93
No Designation	7	18.57	5.32	13	21.23	5.57
Analysis of Variance:	13/419 df			F = 4.421		$p < .01$

TABLE 46

MALE AND FEMALE SEX GROUPS FOR THE 18 EXPERIMENTAL TREATMENTS (ANALYSIS OF VARIANCE)

	Source	df	SS	MS	F	Correlation Ratio	p
Experiment I							
Male	Between	17	1042.37	61.32	.981	.294	---
	Within	177	11053.61	62.45			
	Total	194	12095.98				
Female	Between	17	812.16	47.77	.800	.268	---
	Within	175	10456.42	59.75			
	Total	192	11268.58				
Experiment II							
Male	Between	17	2411.66	141.86	1.648	.373	---
	Within	173	14888.23	86.06			
	Total	190	17299.90				
Female	Between	17	1494.78	87.93	1.195	.302	---
	Within	202	14859.93	73.56			
	Total	219	16354.71				
Experiment III							
Male	Between	17	980.27	57.66	1.401	.334	---
	Within	189	7781.48	41.17			
	Total	206	8761.75				
Female	Between	17	769.32	45.25	1.219	.301	---
	Within	208	7722.84	37.13			
	Total	225	8492.16				

presented in Table 47. There appeared to be no discernible pattern of performance among the 18 treatments related to sex factors.

In order to determine the differential relationships of sex to the three major presentation variables studied, mean post-test scores were compared by analysis of variance. Table 48 presents the data for the two sex groups with the three visual presentation modes. There was no significant sex difference in performance in Experiment I. In Experiment II the male group showed highly significant differences ($p < .01$), performance on the two pictorial presentation modes being superior to that on the printed-verbal mode. Although the female group demonstrated this same pattern of performance, the differences were not statistically significant. In Experiment III the female group showed significant differences ($p < .05$), performance on the printed-verbal mode being higher than on the two pictorial modes.

The interactions of the two sex groups with the three audio presentation modes are shown in Table 49. No significant differences for any of the groups were found.

The interactions of the two sex groups with the two programing approaches are shown in Table 50. No significant sex difference was found in Experiment I. In Experiment II the female group showed significantly superior performance ($p < .05$) on the branching mode, but in Experiment III the males showed this superiority ($p < .05$).

It would appear, from a study of all the results for the sex groups, that the males may have profitted slightly more than the females from the pictorial presentations (still and motion), but that there were no discernible sex differences for the various audio or programing modes of presentation.

F Battery

Determination of how the High F Battery students (scores greater than the mean) and the Low F Battery students (scores less than the mean) performed on the post-tests in relation to the experimental treatment received was accomplished through separate analyses of variance reported in Table 51 for each of the three experiments. None of the groups

TABLE 47

TOTAL POST-TEST MEAN SCORES AND STANDARD DEVIATIONS FOR MALE AND FEMALE SEX GROUPS

	Experiment I				Experiment II				Experiment III			
	Male		Female		Male		Female		Male		Female	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Print/Silent/Linear	21.46	9.92	21.08	6.96	25.75	7.69	31.08	10.40	20.09	7.42	24.38	2.47
Print/Silent/Branching	18.00	2.12	21.67	8.50	29.33	11.19	31.36	5.92	21.27	5.62	22.38	6.27
Print/Redundant/Linear	18.11	5.37	19.18	7.97	25.64	7.50	28.50	6.96	18.36	6.21	23.58	6.42
Print/Redundant/Branching	26.00	6.98	21.00	11.44	25.00	8.29	30.22	12.36	21.07	5.65	19.75	5.71
Print/Directive/Linear	22.86	8.74	22.70	5.87	29.36	9.92	32.33	9.12	22.75	6.24	23.00	7.86
Print/Directive/Branching	22.09	6.79	22.18	5.98	29.00	8.54	32.77	7.21	22.83	6.26	23.29	6.94
Graphic/Silent/Linear	21.42	7.17	19.90	9.12	27.56	12.03	32.07	8.92	18.58	7.76	21.15	5.19
Graphic/Silent/Branching	21.56	6.73	21.73	8.67	33.75	9.47	35.23	7.54	21.75	7.15	18.69	7.35
Graphic/Redundant/Linear	24.00	5.89	22.30	6.40	34.20	8.55	29.43	9.81	17.42	4.44	18.08	6.34
Graphic/Redundant/Branching	23.18	6.11	21.00	10.33	33.00	8.85	32.17	9.68	18.20	5.81	21.18	4.51
Graphic/Directive/Linear	23.20	9.41	25.00	6.80	31.30	5.72	33.83	9.43	20.36	7.30	21.00	5.64
Graphic/Directive/Branching	19.89	9.53	26.83	7.77	32.09	9.06	35.62	6.90	24.27	5.87	22.20	5.65
Motion/Silent/Linear	26.36	10.62	21.08	8.17	34.69	8.60	32.18	9.38	23.00	6.03	21.42	6.19
Motion/Silent/Branching	22.78	7.08	22.90	8.66	30.77	12.40	36.18	6.91	20.75	5.77	22.58	5.07
Motion/Redundant/Linear	18.83	6.91	25.36	6.09	29.82	12.34	36.29	7.38	17.67	7.57	19.77	6.64
Motion/Redundant/Branching	24.92	8.88	22.30	6.11	35.36	7.42	36.23	10.11	24.10	6.10	21.50	6.43
Motion/Directive/Linear	23.58	9.04	18.36	5.50	38.40	3.34	28.58	7.22	18.64	4.20	22.80	6.03
Motion/Directive/Branching	22.00	8.31	22.18	7.40	30.90	11.04	36.00	6.85	23.22	8.97	18.00	6.44
Total	22.34	7.90	22.05	7.66	30.85	9.54	32.74	8.64	20.72	6.52	21.40	6.14

TABLE 48

COMPARISON OF POST-TEST MEANS FOR MALE AND FEMALE SEX GROUPS FOR VISUAL PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Printed-Verbal			Still-Graphic			Motion-Picture			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
Male	68	21.75	7.65	60	22.22	7.38	67	23.06	8.62	2/192	.473	-----
Female	65	21.29	7.58	63	22.87	8.29	65	22.00	7.13	2/190	.681	-----
Experiment II												
Male	64	27.23	8.70	59	32.02	8.91	68	33.25	9.93	2/188	7.693	$< .01$
Female	72	31.03	8.55	79	32.99	8.76	69	34.23	8.40	2/217	2.508	-----
Experiment III												
Male	74	21.00	6.22	68	20.09	6.69	65	21.06	6.73	2/204	.474	-----
Female	77	22.77	6.16	71	20.27	5.88	78	21.08	6.18	2/223	3.282	$< .05$

TABLE 49

COMPARISON OF POST-TEST MEANS FOR MALE AND FEMALE SEX GROUPS FOR AUDIO PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Silent			Redundant			Directive			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
Male	63	22.02	8.08	67	22.37	8.40	65	22.63	7.27	2/192	.097	-----
Female	68	21.38	8.04	65	22.88	6.89	60	21.90	8.04	2/190	.646	-----
Experiment II												
Male	64	30.34	10.42	62	31.81	8.63	65	30.45	9.54	2/188	.457	-----
Female	74	32.97	8.34	70	33.06	7.98	76	32.21	9.56	2/217	.215	-----
Experiment III												
Male	69	20.88	6.59	66	22.00	6.56	72	19.39	6.25	2/204	2.843	-----
Female	76	21.76	5.72	75	21.81	6.56	75	20.61	6.14	2/223	.917	-----

TABLE 50

COMPARISON OF POST-TEST MEANS FOR MALE AND FEMALE SEX GROUPS FOR PROGRAMING MODES (ANALYSIS OF VARIANCE)

	Linear			Branching			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I									
Male	102	22.22	8.42	93	22.48	7.32	1/193	.056	-----
Female	99	21.65	7.16	94	22.47	8.17	1/191	.553	-----
Experiment II									
Male	97	30.72	9.37	94	30.99	9.76	1/189	.037	-----
Female	117	31.58	8.83	103	34.05	8.27	1/218	4.538	$< .05$
Experiment III									
Male	106	19.59	6.52	101	21.90	6.34	1/205	6.647	$< .05$
Female	115	21.70	6.11	111	21.08	6.19	1/224	.580	-----

TABLE 51

HIGH AND, LOW F BATTERY GROUPS FOR THE 18 EXPERIMENTAL TREATMENTS
(ANALYSIS OF VARIANCE)

	Source	df	SS	MS	F	Correlation Ratio	P
Experiment I							
High F Battery	Between	17	875.93	51.51	.841	.301	---
	Within	144	8818.61	61.24			
	Total	161	9694.33				
Low F Battery	Between	17	648.16	38.13	.818	.250	---
	Within	208	9692.15	46.60			
	Total	225	10340.31				
Experiment II							
High F Battery	Between	17	1436.67	84.51	1.617	.344	---
	Within	205	10714.75	52.27			
	Total	222	12151.42				
Low F Battery	Between	17	1201.24	70.66	.943	.294	---
	Within	170	12742.57	74.96			
	Total	187	13943.80				
Experiment III							
High F Battery	Between	17	519.63	30.57	.939	.251	---
	Within	238	7747.37	32.55			
	Total	255	8267.00				
Low F Battery	Between	17	573.78	33.75	1.081	.322	---
	Within	159	4964.19	31.22			
	Total	176	5537.98				

for any of the experiments showed statistically significant differences.

The total mean scores and standard deviations for the performance post-test, tabulated for each F Battery group, are presented in Table 52. There appeared to be no discernible pattern of performance among the 18 treatments related to F Battery factors.

In order to determine the differential relationships of F Battery score to the three major presentation variables studied, mean post-test scores were compared by analysis of variance. Table 53 presents the data for the two F Battery groups with the three visual presentation modes. The only significant difference in performance ($p < .001$) was for the High F Battery group in Experiment II, performance on the two pictorial modes being superior to that on the printed-verbal mode. Although the Low F Battery group demonstrated this same pattern of performance, the differences were not statistically significant.

The interactions of the two F Battery groups with the three audio presentation modes are shown in Table 54 and with the two programing approaches in Table 55. No significant differences for any of the comparisons were found.

It would appear, from a study of all the results for the F Battery groups, that the subjects' figural aptitude, as measured by the F Battery, showed little or no relationship to the learning of content having different kinds of visual, audio, programing, or content inherency characteristics.

TABLE 52

TOTAL POST-TEST MEAN SCORES AND STANDARD DEVIATIONS FOR TREATMENT GROUPS AND HIGH AND LOW F BATTERY GROUPS

	Experiment I				Experiment II				Experiment III			
	High F Bat.		Low F Bat.		High F Bat.		Low F Bat.		High F Bat.		Low F Bat.	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Print/Silent/Linear	24.82	6.08	18.67	9.08	31.77	8.51	25.00	9.39	24.64	4.09	19.30	6.24
Print/Silent/Branching	21.22	8.79	19.25	4.88	30.87	9.58	29.20	4.44	23.60	4.68	13.25	2.63
Print/Redundant/Linear	24.29	8.38	15.69	3.09	31.36	6.39	24.00	6.20	20.79	7.39	20.75	6.18
Print/Redundant/Branching	29.40	7.11	18.60	7.71	35.50	7.86	21.92	8.13	23.67	4.64	17.71	4.95
Print/Directive/Linear	27.71	6.73	20.76	7.04	35.36	5.35	26.83	10.64	24.76	5.55	18.88	8.36
Print/Directive/Branching	25.75	7.69	20.07	4.30	34.36	5.64	26.11	8.48	25.33	4.94	20.00	7.33
Graphic/Silent/Linear	22.20	7.52	19.50	8.40	35.50	7.19	25.25	10.39	23.54	6.29	16.00	4.24
Graphic/Silent/Branching	24.78	7.36	19.09	7.22	37.75	3.55	30.56	10.20	22.62	7.50	17.50	6.26
Graphic/Redundant/Linear	24.33	5.66	22.00	6.48	37.09	7.12	26.62	8.57	21.14	5.27	16.44	5.00
Graphic/Redundant/Branching	24.63	9.61	20.62	7.26	37.83	6.56	26.82	8.06	21.67	5.03	17.22	4.66
Graphic/Directive/Linear	25.69	7.04	21.63	9.26	35.36	8.23	30.00	6.87	21.13	6.22	19.50	7.23
Graphic/Directive/Branching	25.50	10.43	22.50	8.33	36.36	9.10	32.00	6.61	26.33	4.68	19.22	4.38
Motion/Silent/Linear	31.44	4.30	18.57	8.63	38.33	3.60	28.75	10.06	23.67	5.19	16.80	6.26
Motion/Silent/Branching	25.33	8.29	21.69	7.52	37.53	9.20	26.11	8.51	23.50	4.74	19.10	5.42
Motion/Redundant/Linear	26.00	7.64	20.53	6.69	35.63	9.83	29.56	10.16	22.67	5.66	15.15	6.34
Motion/Redundant/Branching	25.62	9.00	21.00	4.42	39.94	4.89	27.63	9.36	24.75	6.44	18.25	3.01
Motion/Directive/Linear	28.25	8.92	17.27	3.49	37.00	5.18	27.33	6.89	22.84	5.16	16.14	3.80
Motion/Directive/Branching	25.45	8.70	18.73	4.82	38.60	6.43	26.38	8.48	24.00	8.05	15.22	4.06
Total	25.66	7.76	19.71	6.78	35.89	7.40	27.08	8.64	23.44	5.69	17.66	5.61

TABLE 53

COMPARISON OF POST-TEST MEANS FOR HIGH AND LOW F BATTERY GROUP FOR VISUAL PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Printed-Verbal			Still-Graphic			Motion-Picture			df	F	P
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
High F Bat.	52	25.54	7.56	57	24.54	7.66	53	26.98	8.01	2/159	1.370	-----
Low F Bat.	81	18.95	6.44	66	20.83	7.63	79	19.56	6.32	2/223	1.440	-----
Experiment II												
High F Bat.	72	32.99	7.46	69	36.67	6.93	82	37.79	7.03	2/220	9.283	<.001
Low F Bat.	64	25.03	8.32	69	28.48	8.62	55	27.71	8.71	2/185	2.910	-----
Experiment III												
High F Bat.	92	23.84	5.35	73	22.77	6.07	91	23.57	5.74	2/253	.756	-----
Low F Bat.	59	18.88	6.35	66	17.32	5.17	52	16.69	5.08	2/174	2.329	-----

TABLE 54

COMPARISON OF POST-TEST MEANS FOR HIGH AND LOW F BATTERY GROUPS FOR AUDIO PRESENTATION MODES (ANALYSIS OF VARIANCE)

	Silent			Redundant			Directive			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I												
High F Bat.	54	24.89	7.53	55	26.25	7.96	53	25.83	7.87	2/159	.438	-----
Low F Bat.	77	19.44	7.65	77	20.03	6.32	72	19.67	6.33	2/223	.144	-----
Experiment II												
High F Bat.	79	35.16	7.93	70	36.09	6.62	74	36.49	7.54	2/220	.643	-----
Low F Bat.	59	27.19	9.39	62	28.39	8.11	67	25.78	8.35	2/185	1.486	-----
Experiment III												
High F Bat.	92	23.61	5.31	91	23.92	5.87	73	22.62	5.92	2/253	1.133	-----
Low F Bat.	53	17.42	5.51	50	18.22	6.11	74	17.45	5.37	2/174	.351	-----

TABLE 55

COMPARISON OF POST-TEST MEANS FOR HIGH AND LOW F BATTERY GROUPS FOR PROGRAMING MODE (ANALYSIS OF VARIANCE)

	Linear			Branching			df	F	p
	N	$\bar{X}$	σ	N	$\bar{X}$	σ			
Experiment I									
High F Battery	54	24.89	7.53	55	26.25	7.96	1/159	.438	-----
Low F Battery	121	19.27	7.13	105	20.22	6.35	1/224	1.096	-----
Experiment II									
High F Battery	110	35.28	7.26	113	36.49	7.51	1/221	1.482	-----
Low F Battery	104	26.87	8.80	84	27.35	8.47	1/186	.143	-----
Experiment III									
High F Battery	130	22.93	5.70	126	23.96	5.67	1/254	2.101	-----
Low F Battery	91	17.49	5.96	86	17.83	5.24	1/175	.153	-----

CHAPTER VIII

RESULTS: LEARNER RESPONSES

The results of the analysis of the responses made by the subjects during the programs in Experiments I and II are presented in this chapter. These data were recorded on an IBM card punch for each subject as he made each response (pressing a key on the response panel) and consisted of total time to complete the program and number of errors made.

The total mean times taken to complete the programs and the mean numbers of response errors made for each of the treatment groups are presented in Table 56, and for the combined groups in Table 57. Examination of these tables shows no consistent pattern between the two experiments. However, some of the results disclosed differences that will be discussed in the following sections.

Time to Complete Program

As expected, the branching programs took longer to complete than the linear programs. In Experiment I, the mean time needed to complete the linear program was 37 minutes 25 seconds and to complete the branching program 41 minutes 28 seconds. In Experiment II, a total of 29 minutes 45 seconds were needed for the linear program and 35 minutes 54 seconds for the branching program. Thus, the remedial branching sequences used in the two experiments added about 11% and 21%, respectively, to the time needed to work the programs.

When the time used was compared for the three visual presentation modes, there was a variation of less than one minute for the linear treatments and about four and one-half minutes for the branching treatments in Experiment I. However, in Experiment II, the printed-verbal group needed over thirteen minutes longer than the other two treatments for the linear

TABLE 56

MEAN TIME (IN SECONDS) TAKEN TO COMPLETE PROGRAMS AND MEAN NUMBER OF RESPONSE ERRORS FOR ALL TREATMENT GROUPS (EXPERIMENTS I AND II)

	Experiment I (N = 374)					Experiment II (N = 445)				
	N	Main Line Time	Branching Time	Combined Total Time	Mean Errors	N	Main Line Time	Branching Time	Combined Total Time	Errors
Print/Silent/Linear	30	2195		2195	4.08	24	2217		2217	1.50
Print/Silent/Branching	21	2148	534	2682	2.43	23	2207	528	2735	2.04
Print/Redundant/Linear	19	2157		2157	2.63	27	2289		2289	.74
Print/Redundant/Branching	20	2151	227	2377	2.20	23	2355	426	2782	1.52
Print/Directive/Linear	20	2356		2356	1.40	24	2473		2473	1.04
Print/Directive/Branching	21	2236	255	2491	2.67	25	2459	411	2871	1.64
Graphic/Silent/Linear	21	2158		2158	3.76	25	1502		1502	.96
Graphic/Silent/Branching	21	2339	380	2719	3.24	23	1580	267	1847	1.22
Graphic/Redundant/Linear	22	2111		2111	1.91	28	1412		1412	.75
Graphic/Redundant/Branching	23	2241	255	2496	2.78	24	1361	355	1715	1.75
Graphic/Directive/Linear	21	2394		2394	2.24	26	1824		1824	.88
Graphic/Directive/Branching	18	2420	208	2628	2.33	23	1653	390	2044	1.70
Motion/Silent/Linear	17	2293		2293	3.88	28	1554		1554	1.00
Motion/Silent/Branching	21	2140	298	2438	2.29	27	1481	345	1825	1.67
Motion/Redundant/Linear	23	2224		2224	4.09	26	1341		1341	1.04
Motion/Redundant/Branching	22	1887	235	2122	2.27	24	1254	316	1570	1.79
Motion/Directive/Linear	20	2335		2335	3.35	21	1648		1648	1.29
Motion/Directive/Branching	23	2228	240	2468	2.00	24	1693	349	2042	1.67

TABLE 57

MEAN TIME (IN SECONDS) TAKEN TO COMPLETE PROGRAMS AND MEAN NUMBER OF RESPONSE ERRORS FOR COMBINED GROUPS (EXPERIMENTS I AND II)

	Experiment I			Experiment II		
	N	Mean Time	Mean Errors	N	Mean Time	Mean Errors
Visual Presentation						
Print/Linear	63	2234	2.78	75	2325	1.07
Graphic/Linear	64	2222	2.63	79	1538	.86
Motion/Linear	60	2282	3.78	75	1507	1.09
Print/Branching	62	2519	2.44	71	2798	1.73
Graphic/Branching	62	2609	2.87	70	1867	1.56
Motion/Branching	66	2343	2.18	75	1813	1.71
Audio Presentation						
Silent/Linear	62	2209	3.92	77	1744	1.14
Redundant/Linear	64	2165	2.97	81	1681	.84
Directive/Linear	61	2362	2.33	71	1991	1.04
Silent/Branching	63	2613	2.65	73	2119	1.71
Redundant/Branching	65	2333	2.43	71	2012	1.69
Directive/Branching	62	2522	2.32	72	2330	1.67
Programing Approach						
Linear	187	2245	3.05	229	1785	1.00
Branching	190	2488	2.48	216	2154	1.69

versions and fifteen and one-half minutes for the branching versions. These results might suggest that the presentation of inherently concrete referent material (such as that presented in Experiment II) could be made more rapidly in the pictorial modes (still-graphic and motion-picture) than in the printed mode. However, this time saving appeared to be a function of length, for the printed-verbal had about a third more frames than the two pictorial versions.

When the time used was compared for the three audio presentation modes, the variation among the modes for each experiment were more nearly the same for linear and branching and for each experiment, ranging from about three to five minutes. In all cases, the Redundant mode was completed more rapidly, perhaps because the pacing was built-in.

From the results of the analysis of time used to complete the programs, it would appear that the time taken was more a function of the physical characteristics of the programs than of particular interactions of the variables being studied. In other words, the comparative times to complete the programs could be predicted on the basis of their lengths in frames, the programing approach used (linear or branching), and the time restrictions imposed by the use of sound.

Response Error Rate

The error rate for student responses was computed on the basis of incorrect responses made to multiple-choice questions, which were similar for the linear and branching treatments. These decision points tended to be summary-type questions and were punched into the IBM cards upon activation of the response keys. In the linear treatments the subject could make only one error at any one decision point, for he was fed back the correct answer immediately. In the branching treatments, however, it was possible for the subject to make as many as three errors at any one branching point; for, if he made another wrong response at the end of any remedial branch, he was given one or two additional remedial branches until he made the correct response. Only the IBM punch card machine-recorded multiple-choice responses were analyzed; the overt and covert constructed responses were not tabulated. The results of this analysis are presented in Tables 56 and 57.

For the eight decision points in Experiment I, 3.05 mean errors were made by the linear treatment groups and 2.48 by the branching treatment groups. For the three decision points in Experiment II the results were reversed, 1.00 mean errors being made by the linear treatment groups and 1.69 for the branching treatment groups. This same reversal generally held for the interactions between the programing modes and the visual or audio presentations.

In Experiment I, the motion/linear visual presentation mode and the silent/linear audio presentation mode produced the highest number of response errors and the motion/branching and the two directive sound treatments the lowest number. In Experiment II, the variation among any of the treatment groups did not appear to be great.

From the results of the analysis of response error rate for the two experiments together, no discernible trends could be found.

CHAPTER IX

RESULTS: CONTENT INHERENCY

The relationships of the inherent dominant characteristics of the content to the different modes of presentation of the stimuli were determined by inspection and interpretation of the results for all three experiments. The comparison of adjusted mean scores for the three visual presentation modes in each experiment are given in Table 58. The results will be separately considered for each of the three experiments.

Non-Concrete Referent Content
(Experiment I)

This content consisted predominantly of verbal concepts for which there were no direct "concrete" referents in the stimuli. It was hypothesized that, because the content dealt with verbal and non-concrete material, the supplementation of the printed-verbal program by either still or motion pictorial illustrations would contribute little or nothing to the learning of the content as measured by the performance post-test. This hypothesis was supported by the results. There were no significant differences in performance for the three visual presentation mode groups, although the two pictorial treatments resulted in slightly higher post-test scores than did the printed-verbal treatment. Neither did there appear to be any interrelationships between learner characteristics of the subjects and the mode of visual presentation used that differed from the results for the total groups.

Concrete Referent Content
(Experiment II)

This content consisted predominantly of material having referents of a "concrete" nature, such as crystal shapes and

TABLE 58

COMPARISON OF POST-TEST ADJUSTED MEAN SCORES FOR VISUAL PRESENTATION MODES IN THREE EXPERIMENTS (COVARIATES: TOTAL IQ AND TOTAL F BATTERY)

	Printed-Verbal	Still-Graphic	Motion-Picture	Prob.
Experiment I (Non-Concrete Referent)	21.67	22.17	22.69	F = 1.494 N.S.
Experiment II (Concrete Referent)	29.48	32.41	34.02	F = 18.687 $<.001$
Experiment III (Action-Process)	21.58	20.77	20.77	F = 1.258 N.S.

forms, that were describable and picturable by means of pictorial and graphic surrogates. It was hypothesized that, because the content dealt with concrete objects and features, the supplementation of the printed-verbal program by either still or motion pictorial illustrations would contribute significantly to the learning of the content as measured by the performance post-test. This hypothesis was supported by the results. As shown in Table 58, there were highly significant results favoring the still-graphic and motion-picture treatments over the printed-verbal treatment.

These results, when considered with those in Experiment I, strongly suggest that the superior scores obtained under the pictorial treatment conditions were a function of the characteristics of the subject matter content. For similar pictorial treatment did not increase scores significantly when used as an aid to learning content with non-concrete referents.

When compared with Experiment I, there also appeared to be some interaction between the visual presentation mode used and the content inherency of the material for two of the learner characteristics of the subjects. The male subjects appeared to be influenced more by the presentation mode/content inherency interaction than were the female subjects. For the girls the differences between the printed-verbal scores and the two pictorial (still-graphic and motion-picture) mode scores were only 1.96 and 3.20 and non-significant; but for the boys these differences were 4.79 and 6.02, significant at the .01 level. The same interactions held for the High F Battery group, which had scores differences of 3.68 and 4.80, significant at the .001 level; whereas the Low F Battery group had non-significant score differences of 3.45 and 2.68. But even though these differences were significant, all of the results for the learner characteristics were in the predicted direction, and possibly too much importance should not be given to such results.

Action-Process Content
(Experiment III)

This content emphasized continuous, self-contained action sequences wherein the action comprised a complete act in itself rather than a series of connected but separate acts. It was hypothesized that, because the content dealt with sequences of action and movement, the motion-picture treatment would contribute the most to the learning of the content as measured by the performance post-test. This hypothesis was not supported by the results. There were no significant differences in performance for the three visual presentation mode groups. In fact, a slightly higher score was obtained by the printed-verbal group than for the two pictorial mode groups, contrary to prediction, contributed largely by the female subjects.

The failure of the Action-Process content used in Experiment III to conform to the prediction, but rather to reverse it, will be discussed in Chapter X.

CHAPTER X

CONCLUSIONS AND DISCUSSION OF IMPLICATIONS

This chapter will present the specific conclusions that may be drawn from the data and discuss the exploratory implications of these data and conclusions.

Conclusions

The following conclusions may be made from an analysis of the results of the three experiments together:

1. The learning of subject matter content consisting of material having concrete referents was increased significantly by supplementing printed programed sequences with pictorial (either as still pictures or as motion pictures) illustrations.

2. The mode of visual presentation used (print alone or print supplemented by pictorial) did not appear to affect the learning of subject matter content consisting of material having non-concrete referents or action-process characteristics.

3. None of the three audio presentation modes demonstrated any superiority over the others in any of the three experiments.

4. None of the two programing approaches demonstrated a consistent superiority over the other. Only with the concrete referent material was the difference statistically significant ($p < .05$), favoring the remedial branching approach over the linear approach.

5. There were no consistent patterns of superiority shown for any of relationships between major variables

(visual/audio, visual/programing, or audio/programing) through the three experiments with the single following exception. There was a strong tendency, in all three experiments, for the directive mode of audio presentation to demonstrate a superiority over the other two modes of audio presentation for the two still presentation modes (printed-verbal and still-graphic), but to be least effective in interaction with the motion picture visual presentation mode.

6. There was a definite tendency through the three experiments for the subjects in each of the visual presentation groups (printed-verbal, still-graphic, motion-picture) to perform best on the subtests that were similar in form (verbal, graphic, motion) to the stimulus mode received.

7. There appeared to be little or no consistent patterns of relationships between the modes of presentation used and the characteristics of the learners.

8. There were no discernible relationships between either the time taken to complete the programs or the response error rate and variables being studied.

9. There was a definite relationship affecting learning between the inherency of the content, so far as the concreteness or non-concreteness of the material was concerned, and the visual presentation mode employed as stimuli. Whereas material having content with non-concrete referents was learned as well under all three visual presentation modes, material having content with concrete referents was learned significantly better when presented by the still-graphic and motion-picture pictorial modes than when presented only in the printed-verbal mode.

Discussion of Implications

The three experiments in this study were conducted to explore interrelationships among stimulus presentation variables, the nature of the content being taught, and various characteristics of learners. It was the intent of the study to increase our knowledge of the conditions leading to the optimal design of programed instructional materials, particularly as these related to the employment of still and motion pictorial and graphic materials. The discussion of the results will consider the three major presentation variables and their relationships to the content inherency characteristics of the subject matter material and the characteristics of the learners.

The Visual Presentation Mode

The previous research on the overall effects of still and motion pictorial presentations supported the conclusion that visual presentations could enhance the learning of factual information and concepts. But the precise conditions under which such enhancement would occur have not been clearly defined. The three experiments conducted in this study furnished evidence which may be used to understand more completely some of these conditions. When the results are examined, several facts become clear.

Pictorial implementation, when used to supplement a printed-verbal instructional message, does not automatically produce an increase in the learning of the content presented, as has so often been professed by audiovisualists. Rather, this study obtained evidence suggesting that the inherent characteristics of the subject matter itself was an important factor to consider when predicting what kind of visual presentation should be used most advantageously. The fact that there was no significant advantage for any one of the three visual presentation modes (printed-verbal, still-graphic supplementation, or motion-picture supplementation) in Experiment I, consisting predominantly of "non-concrete" verbal and abstract concepts, suggests that perhaps pictorial implementation can make little or no contribution to learning with such "non-concrete" content. On the other hand, when the content consisted predominantly of material having referents of a "concrete" nature, as in Experiment II, there was a decided advantage attributable to both the still and motion pictorial implementation modes, suggesting that the learning of "concrete" content may be enhanced by using pictorial illustrations. Separate attention will be given later to the results from Experiment III in which the content consisted of materials comprising actions and processes.

The findings from Experiments I and II could have important implications for the design and use of instructional media; for it lends support to a need for a reclassification of media content. Such content is normally classified according to the subject matter involved (i.e., mathematics, social studies, art, science, etc.) on the assumption that the subject matter itself possesses distinct characteristics that distinguish it from other subject matters. The suggested scheme for the reclassification of media content hypothesizes that all subject matter content, regardless of the particular curricular topic involved, possesses inherent characteristics that can be identified and measured. This study did not test the general hypothesis stated above because it treated only one area of subject matter: crystallography in general science. But the evidence obtained suggests that at least one area of subject matter content can be analyzed and the content classified as being either "non-concrete" or "concrete." Furthermore, the evidence showed that such different categories of content interacted differently with the type of visual presentation mode used to present it.

Assuming that the findings from Experiments I and II are valid, new insight is gained as to the conditions under which pictorial implementation may be used to enhance learning, at least in programed instruction. It may be possible to predict that subject matter content having non-concrete referents (abstract content) may profit little from pictorial implementation, but that content having concrete referents will have its instructional effectiveness increased by using the pictorial mode of presentation (motion or still). Such a finding may be of little consequence to the producers of materials or the audiovisual educators who are committed to single channel presentation, but it has direct relevance for the designer of instructional systems where the need exists to match, in the most effective and efficient manner, presentational mode with the content being taught and the instructional objective being served. It should be of prime importance to such producers to know what visual mode of presentation to use under given conditions. For example, deciding whether to produce an expensive motion picture film, a less expensive still filmstrip, or to use printed text alone in order to teach a particular segment of instructional content can have significant influence on the costs, time involved, personnel commitments, and the eventual conditions of instructional use. A different decision may thus be made when there is a learning advantage for one mode over the others than when no learning advantage is apparent.

The results from Experiment III, consisting of materials comprising actions and processes, were not in accord with the hypothesis that content dealing with sequences of action and movement would be more effectively learned under conditions using motion picture stimuli. As reported above, the printed-verbal group performed slightly better on such material than did the two pictorial presentation groups. Such a finding, contrary to the prediction, could mean either that (1) subject matter content cannot be categorized as having "action-process" characteristics, or (2) the sequences selected for presentation were not representative of "action-process" content, or (3) the criterion post-test measured "verbal" concepts rather than concepts inherent in actions and processes, or (4) a combination of the above factors.

The appropriateness of reasons "(1)" and "(4)" cannot be determined at this time, but it appears that the results could have derived from either of the other two factors or a combination of them. It is possible that the requirements of an "action-process" stimulus, as defined in this study, were actually not met in the pictorial sequences. For example, in the sequence illustrating the concept of "spontaneous nucleation," the motion picture and graphic slides showed spontaneous nucleation actually taking place, whereas the printed-verbal version described the action. Although the researchers thought that such an action possessed characteristics in which motion was inherent, it may be that "spontaneous nucleation" is in fact an abstract verbal concept and that "seeing" it occur is immaterial to learning the concept. If we examine the test questions, we discover that the questions relating to "spontaneous nucleation" are answered as readily in the printed-verbal version as in the two pictorial versions. In other words, the questions do not test unique elements of motion in the pictorial supplementation, but rather the larger concept being treated: in this case, the cause of spontaneous nucleation (knocking the container), the characteristics of supersaturated solutions, and the order in which spontaneous nucleation occurs. The expectation of the researchers was that, by presenting the actual occurrence of a process or action in pictorial form, knowledge of the act would be learned more effectively. At least as reflected in the present study, this expectation was not realized. In hindsight, it would appear that, in order to determine whether or not the motion picture mode is the optimum channel for presenting a process in action, those particular elements in the process that are in actual motion and are changing in some way during this movement are appropriate elements for measurement in the criterion test. This would mean that, instead of asking questions about the causes of spontaneous nucleation or the order of its occurrence, the proper questions would be something like: "Describe the appearance of the molecules in a super-saturated solution during spontaneous nucleation as they change from orderly crystal formation to imperfect crystal clusters," or "How rapidly (1 second, 5 seconds, 10 seconds, 30 seconds) do imperfect crystal clusters form during spontaneous nucleation in a super-saturated solution?"

The results of Experiment III suggest further study to determine more precisely the conditions under which content characterized as dealing with action-processes may be most effectively presented and what the expectations of learning are from different presentation modes in relation to the nature of the learning being measured. It seems reasonable that a question testing overt perception of observed movement might be more correctly answered when the learner has physically observed this movement in real life, in a model, or in a motion picture. However, would a similar advantage accrue to such direct observation if the question asked tested the meaning of the movement or its consequences or the concept that the movement illustrated? There is the question of purpose being served by the stimulus object. Such precise measurement was not used in the present study, and this unfortunately resulted in ambiguous results.

The Audio Presentation Mode

The single significant consistent audio presentation mode interaction warrants closer examination. This was the tendency, in all three experiments, for the directive mode of audio presentation to show superiority over the other two audio modes when combined with the two still presentation modes (printed-verbal and still-graphic), but to be least effective when combined with the motion-picture visual presentation mode.

The previous research on "directed attention" by means of audio emphasis showed contradictory results (Allen, 1960; Hoban & Van Ormer, 1950; Lumsdaine, 1963); thus this study contributes some evidence relating to the question. It should be remembered that the "directive" audio mode, under the conditions of this study, consisted of the pointing out of relevant cues in the print and pictorial illustrations appearing on the screen. In the case of the printed-verbal and still-graphic versions, the attention was "directed" while the stimulus material was in view to the learner; but, with the motion-picture versions, the attention was directed prior to the appearance of the motion-picture sequence and made reference to material to follow. This is an important distinction; for it meant that subjects exposed to the two still picture (print and graphic) modes could re-search the visual material presented as a result of the directive message they received in the audio. On the other hand, those subjects exposed to the motion-picture mode had to hold in their minds the particular elements that their attention had been called to. Whether or not the results from the study can be interpreted in the light of these distinctions cannot be determined without further research. But the results, particularly in that they were consistent for all three experiments, do furnish useful evidence regarding the value of the audio attention directive variable.

The superiority of the directive mode of audio presentation in combination with the printed-verbal and still-graphic visual presentation modes suggests that the directing of attention to elements in a still visual (print or pictorial) while the visual is in view of the learner will enhance the learning of the material presented. One might expect that this would be the case, but an interesting consideration is that such directed attention was more effective than both a silent audio (in which the subject merely read the printed-verbal material) or a redundant audio (in which the subject heard the printed-verbal material repeated word-for-word). In short, calling attention to certain elements in the content was not only superior to not doing so, but also superior to a condition where there was total redundant repetition of the content in the audio mode. It might be concluded that the directing of attention to elements in a printed or pictorial message while it is held within the field of view is more effective in promoting learning of the message than presenting the message redundantly in two sensory channels--visual and auditory.

Further research is certainly indicated on the "directed attention" variable. Travers' (1964) comprehensive treatment of this factor reveals the complexity of the variable in learning. The failure of the directive audio to elicit improved learning from the motion-picture versions, contrary to expectation, suggests the need for a more detailed study of the conditions under which "directed attention" may be effective and ineffective in learning from programed sequences and from audio-visual and printed materials.

The Programing Approach

Although the overall comparisons between the linear and remedial branching programing modes showed a statistically significant difference only in Experiment II with the material having concrete referents and favoring the remedial branching approach, there were several results that bear closer study. For, whereas the remedial branching approach was favored with the concrete referent material, the linear approach was favored with the non-concrete referent material in Experiment I (although not significantly), and there were mixed results with the action-process material in Experiment III.

Why these consistent patterns of interactions should prevail in Experiments I and II is not clear, and the problem warrants further investigation. Four of the six interactions with the visual and audio variables in Experiment I favored the linear over the branching approach, the programing/audio silent comparison being significant. However, in Experiment II, all six interactions favored the remedial branching over the linear approach, the programing/audio silent and the programing/visual graphic comparisons being significant. It can be observed that, for the programing/audio silent comparisons, the relationships were reversed for the two experiments, both at a significant level.

Is it possible that the linear mode of presentation, without opportunity for remedial review, is a more effective way of learning the more abstract and non-concrete content? On the other hand, is the remedial branching presentation mode, with its review capability, more effective for learning concrete content? This does not seem likely, but the results from this study suggest that the problem receive further research attention.

Learner Characteristics

The failure to find consistent significant relationships between the characteristics of the learners and the modes of presentation employed was unexpected. It had been felt that groups with lower mental ability, lower socioeconomic status, in non-white ethnic groups, and with higher figural ability would profit more from the two pictorial modes of visual presentation than would those groups who had contrasting characteristics. This expectation was not supported by the evidence.

The tendency for the non-white ethnic group and the lower occupational level groups to profit more from the remedial branching programing approach than did the white ethnic group and those at higher occupational levels in all three experiments was predictable, inasmuch as the former groups might be expected to profit more from the opportunity to review sequences and receive remedial instruction.

Conclusion

This project, having as its major objective the exploratory study of a number of variables relating to the presentation of programed instructional materials in different presentational modes, had a two-fold outcome. One, it demonstrated that, even under very limited conditions of exposure time and with a minimal amount of pictorial implementation, a relationship could be demonstrated between the inherent nature of the subject matter content and the mode of presentation used to display it. Two, its findings suggested profitable lines of future inquiry into the elements of instructional message design leading to the development of more effective instructional materials.

CHAPTER XI

SUMMARY

This study was designed as an exploratory multi-variable pilot investigation of the relationships between modes of presentation of programed instructional materials and the characteristics of the materials themselves and the characteristics of the learners interacting with the materials. As such, it was part of a broad program of research directed toward the development of paradigms of message design as related to an emerging science of instruction.

Objectives

The purpose of the study was to compare the effectiveness of machine-presented programed instruction of eighth grade general science content under the following conditions:

1. By three visual presentation modes: printed-verbal, printed-verbal supplemented by still pictures and graphics, and printed-verbal supplemented by the pictures and graphic set in motion.
2. By three audio presentation modes: silent with no sound, redundant sound repeating the printed material, and directive sound pointing out relevant cues in the visual presentations.
3. By two forms of programed instruction: step-by-step linear approach and the remedial branching approach.
4. With three types of subject matter content: "non-concrete referent" material, "concrete referent" material, and "action-process" material.
5. For learners with different characteristics: IQ,

achievement, figural ability, sex, ethnic, and socioeconomic status.

Procedure

Three parallel experiments were conducted, each involving inherently different subject matter content (nonconcrete referent, concrete referent, action-process). Each experiment combined three visual presentation modes (printed-verbal, still-graphic, motion-picture) with three audio presentation modes (silent, redundant sound, directive sound) and two programing approaches (linear, remedial branching). Thus, each experiment utilized a 3 x 3 x 2 factorial design wherein variables were studied in all possible combinations.

The specially prepared programed learning treatments consisted of 54 separate experimental programed sequences, made up of 18 treatments for each of the three experiments. The subject matter consisted of programed sequences on various facets of the general science topic, "crystallography." Each treatment utilized the visual, audio, and programing modes in all possible combinations (eighteen) for each experiment. The visual materials were prepared as 2" x 2" black and white slides or as 16 mm. black and white motion pictures. The audio materials were prepared for presentation on synchronized magnetic tape or as the sound track on the motion picture film.

The experimental stimulus materials were presented to the subjects individually by means of six specially designed teaching machines housed in a 40-foot trailer which was parked on the grounds of each school. Subjects sat in partitioned booths in the trailer and viewed rear projection screens. The programs were presented a frame at a time (or sequence at a time in the case of motion pictures). Each subject used a five-key response panel to advance the program or select branching choices, wrote constructed responses, on a roll of automatically advanced adding machine tape, and wore headphones for the reception of the recorded sound. Each response and the time of the response were recorded by an IBM card punch.

Subjects were 1232 eighth grade students from four Los Angeles Unified School District junior high schools, randomly assigned to the experimental treatments in each school. Of the total, 639 were girls (51.87 percent) and 593 were boys (48.13 percent). The validity of the randomization procedure was confirmed by a Bartlett's test for the homogeneity of variance, which found no significant differences among IQ means of the subjects for any of the three experiments.

Four measures of performance were used: (1) Performance post-tests were constructed for each experiment and administered immediately after exposure to the experimental stimulus. Each test employed multiple-choice, fill-in, and short answer items, some items in each test involving graphic material and some being presented by motion picture film presented on a screen. Results were analyzed for total post-test scores and for selected subtest scores. (2) A battery of tests comprising a so-called "F Battery" was assembled from standardized tests relating to J. P. Guilford's "Structure of Intellect" model. These tests were selected to measure students' abilities in the figural domain. (3) A semantic differential scale was developed to measure the concept "teaching machine." (4) Data from student responses made during exposure to the experimental stimuli were recorded on IBM punch cards.

Four main types of analysis were performed: correlation analysis, factor analysis, analysis of variance and covariance, and multiple-comparisons by means of the Scheffé test and the t-test.

Results

The results are summarized below for each of the three experiments and for the learner characteristics findings:

1. Experiment I (Non-Concrete Referent Material):

a. Analysis of the major variables (visual, audio, programing) showed no significant differences favoring any of the presentation modes.

b. The directive sound mode, when combined with the printed-verbal or still-graphic materials, was significantly more effective than either the redundant sound or silent modes used with the same visual presentation modes ($p < .01$, $p < .05$).

c. The silent mode of audio presentation was more effective when combined with the linear programing mode than with the remedial branching mode ($p < .05$).

d. Subjects exposed to either the still-graphic or motion-picture presentation mode performed significantly better ($p < .01$) on the four motion-picture subtest items than did those exposed to the printed-verbal presentation mode. In general, for all 18 experimental treatments, positive relationships were shown between motion-picture stimuli and motion-picture test items, and negative relationships between printed-verbal stimuli and motion-picture test items.

2. Experiment II (Concrete Referent Material)

a. Analysis of the visual presentation variable showed statistically significant differences favoring the motion-picture and still-graphic modes over the printed-verbal mode ($p < .01$).

b. Analysis of the programing variable showed the remedial branching mode to be significantly superior to the linear mode ($p < .05$).

c. The variations among the audio presentation modes were not statistically significant.

d. Directive sound appeared to be more effective than redundant sound when used with printed material ($p < .05$).

e. The branching-linear interaction favored the branching treatment only in the visual presentation of still-graphic stimuli ($p < .05$).

f. The branching programing mode was favored over the linear mode in the audio presentation only with the silent treatment ($p < .01$).

g. Subjects exposed to either the still-graphic or motion-picture mode performed significantly better ($p < .01$) on the three graphic subtests than did those exposed to the printed-verbal presentation mode.

There was also a tendency for the motion-picture group to show superiority to the other two groups on the motion-picture subtest and the printed-verbal to show superiority on the verbal subtest. Also, negative relationships were shown between still-graphic and motion-picture stimuli and the verbal test items, and between the printed-verbal stimuli and the graphic, slide presentation, and motion-picture test items.

3. Experiment III (Action Process Material):

   a. Analysis of the major variables (visual, audio, programing) showed no significant differences favoring any of the presentation modes, although there was a tendency for the printed-verbal mode to be more effective than the two pictorial modes and the redundant sound to be the least effective of the audio presentation modes.

   b. Directive sound appeared to be more effective than redundant sound when used with either printed ($p < .05$) or still-graphic ($p < .01$) materials.

   c. The branching programing mode was favored over the linear mode in the audio presentation only with the redundant sound treatment ($p < .05$).

   d. Subjects exposed to the printed-verbal mode performed significantly better ($p < .01$) on the seventeen verbal subtest items than did those exposed to either of the two pictorial presentation modes.

   e. The measure of attitude toward the concept "teaching machine" showed the still-graphic, motion-picture, and redundant sound modes of presentation were more "active" than the others and that the teaching machines as such were evaluated positively.

4. Learner Characteristics

   a. The High IQ groups performed at a significantly higher level than did the Low IQ groups for all three experiments, but the IQ level itself showed little or no relationship to the learning of content having different kinds of visual, audio, programing, or content inherency characteristics.

b. There were significant differences in performance for the four ethnic groups for all experiments, the Caucasian and Oriental-American groups showing superior performance to the Negro and Mexican-American groups.

c. When the four ethnic groups were categorized into White and Non-White, with the Oriental-Americans omitted, there was a tendency for the Non-White ethnic group to perform best under conditions which used the remedial branching programing approach.

d. There were significant differences in performance among the six occupational groups (parents' occupation), with the higher occupational levels demonstrating the higher performance. However, there were no discernible differences in performance for any of the three groups under the different stimulus conditions, with the one exception that students with parents in the lower occupational levels showed a slight tendency to perform better under stimulus conditions that used remedial branching.

e. The male subjects may have profitted slightly more than the female subjects from the two pictorial presentation modes, but these differences were not significant, and there were no sex differences for the various audio and programing modes of presentation.

f. Subjects with high figural ability (as measured by the F Battery) performed at a significantly higher level than did those with low figural ability, but the figural ability level itself showed little or no relationship to the learning of content having different kinds of visual, audio, programing, or content inherency characteristics.

5. Learner Responses:

a. It appeared that the time taken to complete the programs was more a function of the physical characteristics of the programs than of particular interactions of the variable being studied.

b. There were no discernible trends from the analysis of response error rate.

6. Content Inherency:

a. There were no significant interactions of content consisting predominantly of material having non-concrete referents and the mode of visual presentation used.

b. Content consisting predominantly of material having concrete referents was learned more effectively when presented by means of the still-graphic and motion-picture pictorial modes.

c. There were no significant interactions of content consisting predominantly of material having action-process characteristics and the mode of visual presentation used.

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APPENDIX A

EXAMPLES OF PROGRAM SEQUENCES

COMPARISON OF PRINTED-VERBAL AND STILL-GRAPHIC VISUAL PRESENTATION MODES IN THE LINEAR PROGRAMING MODE

(Experiment I: Non-Concrete Referent)

EXPLANATION: When the slide is first projected in the linear mode, a shutter covers the correct answer, shown at the bottom of six of the frames in this sequence. When the subject makes his answer choice by pressing the appropriate answer key, the shutter raises and the correct answer is disclosed. The subject then presses the ADVANCE key to go on to the next frame. The "motion-picture" mode, not shown here, is identical to the "still-graphic" except that the different parts of the visual graphics pop in and the printed material is presented before and/or after each visual motion picture sequence.

Printed-Verbal

Crystals are solids. But not all _____ are crystals.

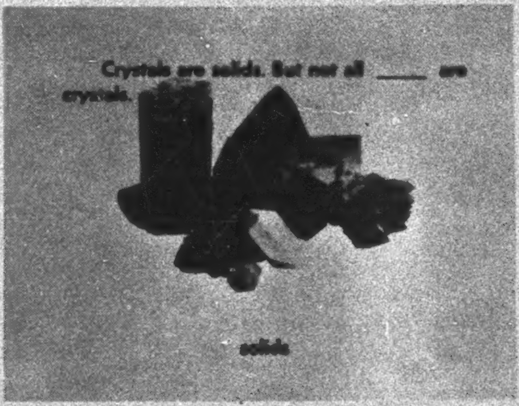
solids

Solids whose atoms are mixed up are called AMORPHOUS solids.

Hence, there are two kinds of solids, crystalline solids and _________ solids.

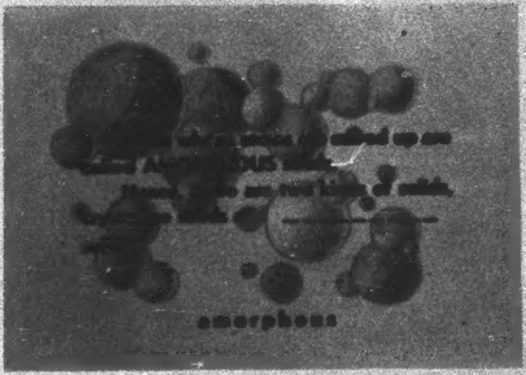
amorphous

Still-Graphic



Crystals are solids. But not all _____ are crystals.

solids



amorphous

Printed-Verbal

Below are all the letters that spell this word which describes solid matter when the atoms are not arranged in definite order.

Rearrange the following letters to spell the word correctly. PMOHORASU

amorphous

Say this word

a MOR phous

The correct spelling of the word you have just studied is

A. amorphous
B. amorphus
C. amphourous
D. amphorus

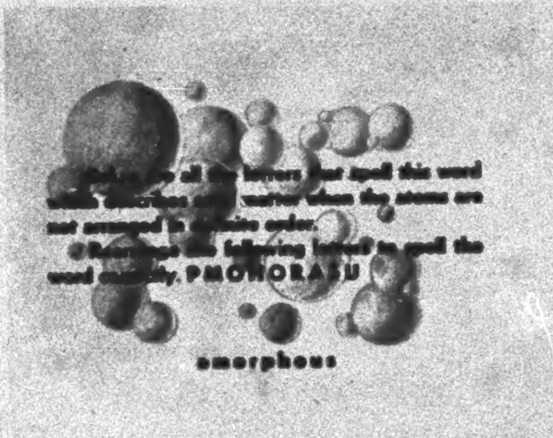
A. amorphous

Unlike crystalline solids, amorphous solids have their _____ all mixed up.

Amorphous solids cannot be crystalline solids.

atoms

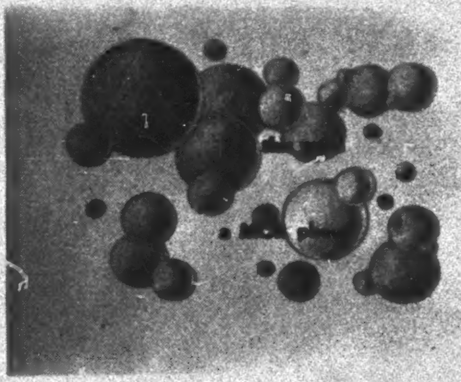
Still-Graphic



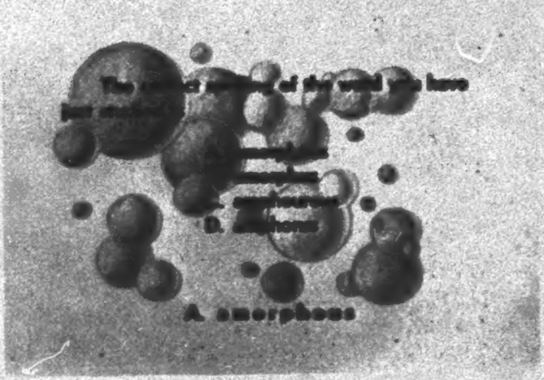
Below are all the letters that spell this word which describes solid matter when the atoms are not arranged in definite order.

Rearrange the following letters to spell the word correctly. PMOHORASU

amorphous



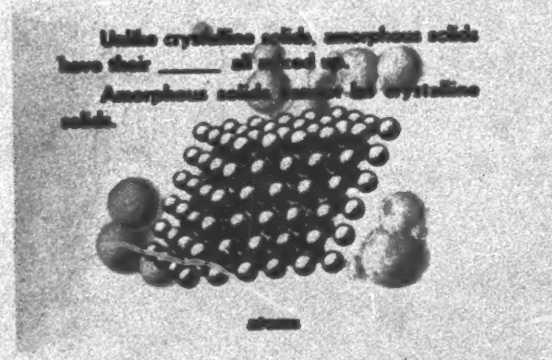
a MOR phous



The correct spelling of the word you have just studied is

D. amphorus

A. amorphous



Unlike crystalline solids, amorphous solids have their _____ all mixed up.

Amorphous solids cannot be crystalline solids.

atoms

A-3

Printed-Verbal

Amorphous solids are not very neat with their internal housekeeping.

What may we observe that tells us this?

(THINK!)

We can see their atoms are all mixed up.

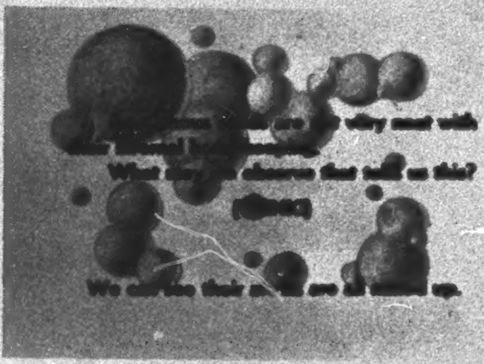
The solids dealt with in crystallography have atoms which are arranged in an orderly fashion.

Amorphous materials do not have an orderly structure of atoms.

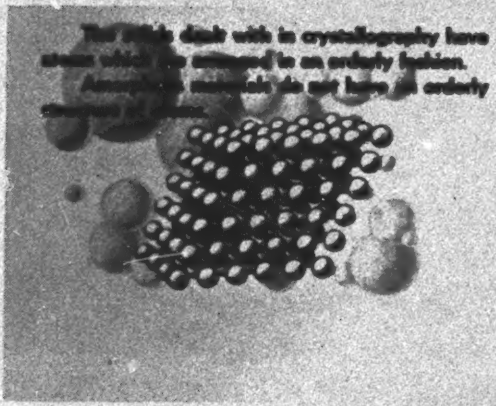
Crystallography deals with amorphous solids.

A. True
B. False

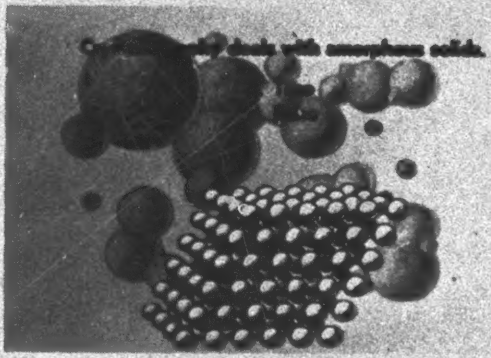
Still-Graphic



Amorphous solids are not very neat with their internal housekeeping.
What may we observe that tells us this?
(THINK!)
We can see their atoms are all mixed up.



The solids dealt with in crystallography have atoms which are arranged in an orderly fashion.
Amorphous materials do not have an orderly structure of atoms.



Crystallography deals with amorphous solids.

COMPARISON OF PRINTED-VERBAL AND STILL-GRAPHIC VISUAL PRESENTATION MODES IN THE BRANCHING PROGRAMING MODE

(Experiment I: Non-Concrete Referent)

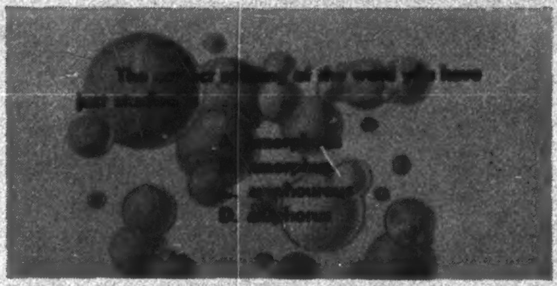
EXPLANATION: The four possible branch choices are shown here in A, B, C, D, order for convenience. However, the choices may be made in any order, and the student may go through all four branching options.

Printed-Verbal

The correct spelling of the word you have just studied is

A. amorphous
B. amorphus
C. amphourous
D. amphorus

Still-Graphic



Your spelling is correct.
Now we will learn about crystal systems.

A
BRANCH

Your spelling is correct.
Now we will learn about crystal systems.

If the "A" key is selected (the correct answer), the student will advance to the next sequence and by-pass the other three branching choices. If the "B" key is selected (incorrect) the following slide will appear:

Printed-Verbal | **Still-Graphic**

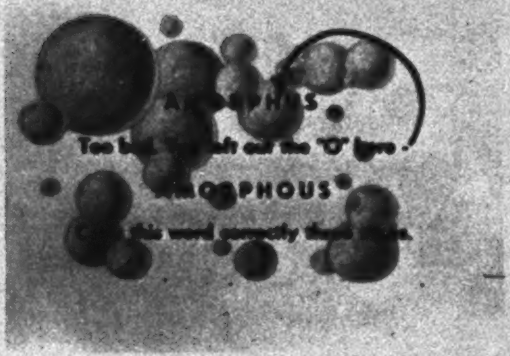
AMORPHUS

Too bad. You left out the "O" here.

AMORPHOUS

Copy this word correctly three times.

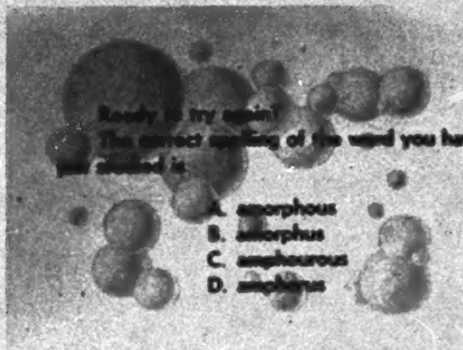
B
BRANCH



AMORPHUS
Too bad. You left out the "O" here.
AMORPHOUS
Copy this word correctly three times.

Ready to try again?
The correct spelling of the word you have just studied is

A. amorphous
B. amorphus
C. amphourous
D. amphorus



Ready to try again?
The correct spelling of the word you have just studied is
A. amorphous
B. amorphus
C. amphourous
D. amphorus

If the student makes the correct selection this time ("A"), he will be shown the "A" Branch slide ("Your spelling is correct. Now we will learn about crystal systems.") and returned to the main-line program. If, however, the "C" key is selected (incorrect), the following slide will appear:

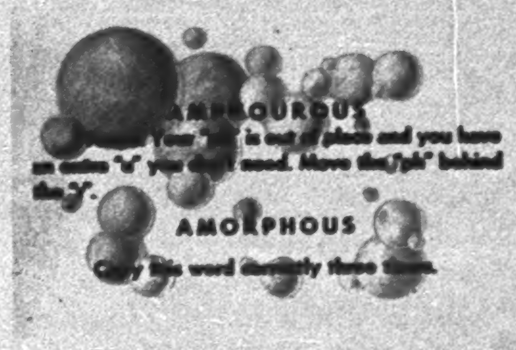
AMPHOUROUS

Woops! Your "ph" is out of place and you have an extra "u" you don't need. Move the "ph" behind the "r".

AMORPHOUS

Copy this word correctly three times.

C
BRANCH



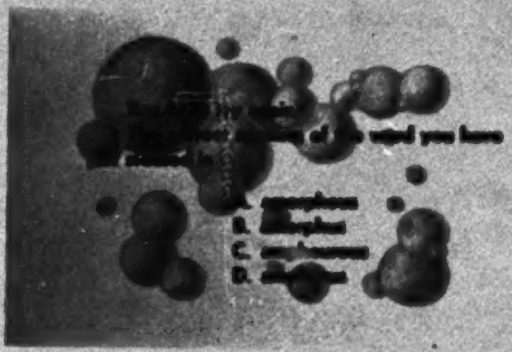
AMPHOUROUS
Woops! Your "ph" is out of place and you have an extra "u" you don't need. Move the "ph" behind the "r".
AMORPHOUS
Copy this word correctly three times.

Printed Verbal

Still-Graphic

Ready to try again?
The correct spelling of the word you have just studied is

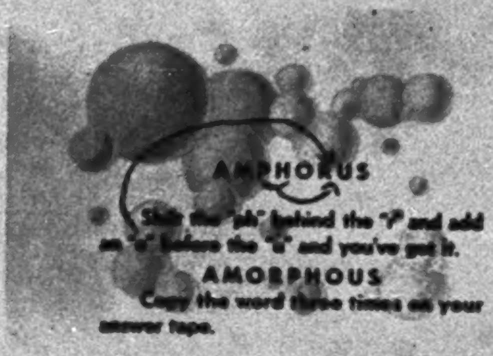
A. amorphous
B. amorphus
C. amphourous
D. amphorus



If the student makes the correct selection this time ("A"), he will be shown the "A" Branch slide and returned to the main-line program. If, however, the "D" key is selected (incorrect), the following slide will appear:

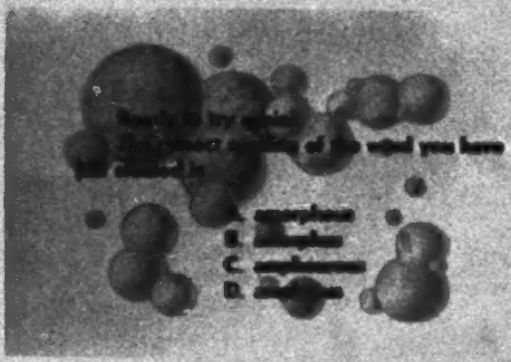
AMPHORUS
Shift the "ph" behind the "r" and add an "o" before the "u" and you've got it.
AMORPHOUS
Copy the word three times on your answer tape.

D
BRANCH



Ready to try again?
The correct spelling of the word you have just studied is

A. amorphous
B. amorphus
C. amphourous
D. amphorus



If the student makes the correct selection this time ("A") or if he exhausts all three incorrect branching possibilities ("B", "C", "D"), he will be returned to the main-line program, which will continue until the next branching sequence.

COMPARISON OF REDUNDANT AND DIRECTIVE AUDIO PRESENTATION MODES IN THE LINEAR PROGRAMING MODE

(Experiment I: Non-Concrete Referent)

EXPLANATION: The "redundant" sound is narrated simultaneously with the appearance of the printed slide, a beep sounding in place of the omitted word in the stimulus. On the feedback, the correct answer is spoken as the shutter reveals the correct answer in print. In the "directive" sound treatment, the student is given time to read the print without sound. Then the "directive" narration is spoken.

Printed-Verbal Visual	**Audio**
Solids whose atoms are mixed up are called AMORPHOUS solids. Hence, there are two kinds of solids, crystalline solids and __________ solids. amorphous	**Redundant**: (Identical to print) **Directive**: "Be sure you notice the spelling of this new word, AMORPHOUS."
Below are all the letters that spell this word which describes solid matter when the atoms are not arranged in definite order. Rearrange the following letters to spell the word correctly. PMOHORASU amorphous	**Redundant**: (Identical to print) **Directive**: (No directive sound)

Printed-Verbal Visual	Audio
Say this word a MOR phous	**Redundant:** (Identical to print) **Directive:** "The PH is an F sound: a-MOR-fus
The correct spelling of the word you have just studied is A. amorphous B. amorphus C. amphourous D. amphorus A. amorphous	**Redundant:** (Identical to print) **Directive:** (No directive sound)
Unlike crystalline solids, amorphous solids have their ______ all mixed up. Amorphous solids cannot be crystalline solids. atoms	**Redundant:** (Identical to print) **Directive:** "Be sure you understand the difference between these two kinds of solids."
Amorphous solids are not very neat with their internal housekeeping. What may we observe that tells us this? (THINK!) We can see their atoms are all mixed up.	**Redundant:** (Identical to print) **Directive:** "Imagine what the inside of an amorphous solid is like."

COMPARISON OF PRINTED-VERBAL AND STILL-GRAPHIC
VISUAL PRESENTATION MODES
IN THE LINEAR PROGRAMING MODE

(Experiment II: Concrete Referent)

EXPLANATION: The same explanation as that given above for the linear programing made in Experiment I pertains here. In addition, it should be noted that the printed material varies between the visual presentation modes because the "printed-verbal" mode requires additional frames to describe what is seen pictorially in the "still-graphic" mode. Although gaps appear below in the sequencing of the frames, such spacing is made only to illustrate points of coincidence between the modes. In actual practice, each program for each mode runs consecutively without a break.

Printed-Verbal

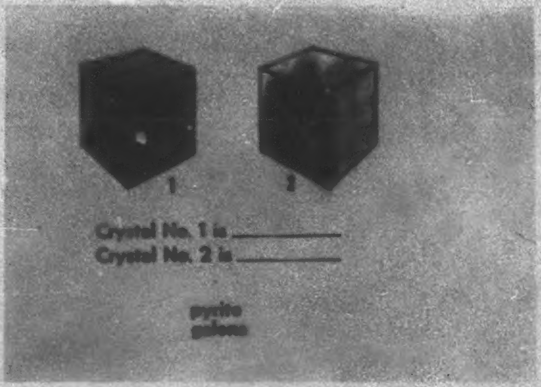
C.2.11

Cube shaped Smooth surface Brownish color 1	Cube shaped Ridged surface Brownish color 2

Crystal No. 1 is__________
Crystal No. 2 is__________
We tell these crystals apart by their__________

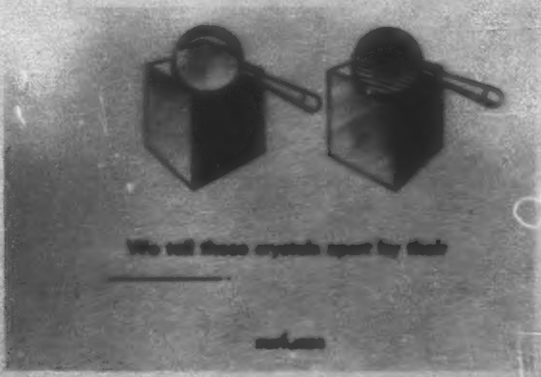
galena
pyrite
surfaces

Still-Graphic



Crystal No. 1 is__________
Crystal No. 2 is__________

pyrite
galena



We tell these crystals apart by their
____

surfaces

Printed-Verbal

2.12

QUARTZ
(pronounced
QUAR-ITS)

BERYL
(pronounced
BARREL)

Write down the names of these two new crystals on your answer tape.

They have pointed ends and rectangular bodies.

QUARTZ **BERYL**

Both of these crystals have hard, shiny ________.

Therefore, we can state that their surfaces are similar.

surfaces

C.2.13.1

They have similar shapes with ________ ends and rectangular ________.
(ends/bodies)

pointed
bodies

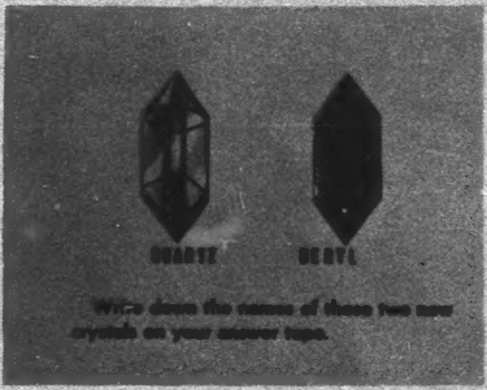
2.13.2

QUARTZ **BERYL**

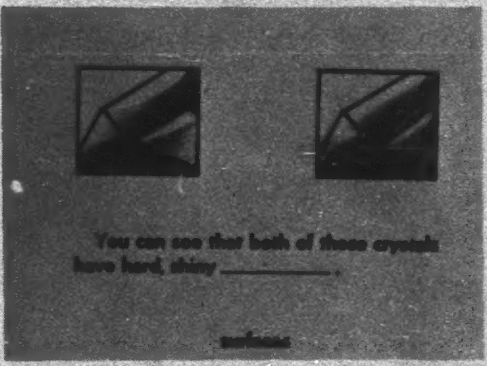
Also since they have the same shape, their faces, edges, and ________ are approximately in the same positions.

corners

Still-Graphic

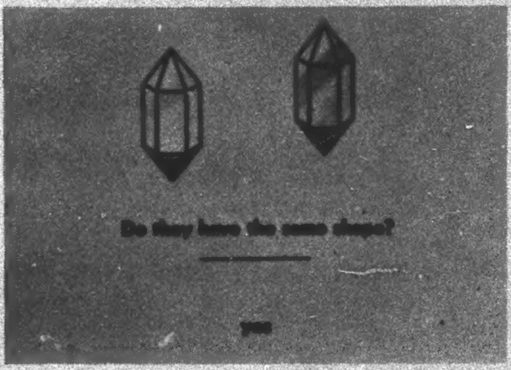
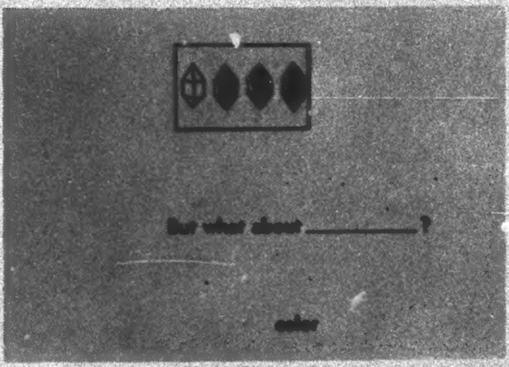
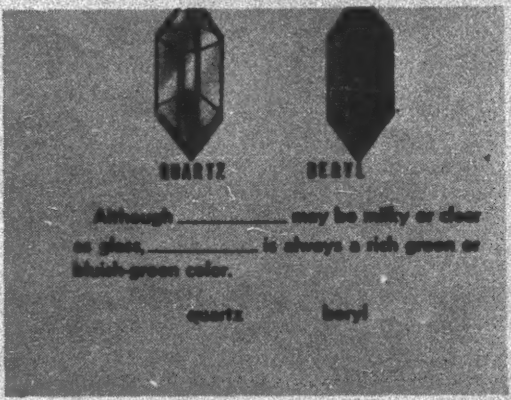


Write down the names of these two new crystals on your answer tape.



You can see that both of these crystals have hard, shiny ________.

surfaces

Printed-Verbal	Still-Graphic
Therefore, we may say that quartz and beryl have the same ______s and surfaces. shapes	Do they have the same shape? ______ yes
.2.15 But what about the third quality, that of color? Remember we tried to identify crystals by their shape, ______, and ______ surface color	But what about ______? color
.2.16 Although quartz may be milky or clear as glass, beryl is always a rich green or bluish-green color. One has a color ______ from the other. (the same/different) different	 Although ______ may be milky or clear as glass, ______ is always a rich green or bluish-green color. quartz beryl
.2.16.1 Both have pointed ends and rectangular bodies. One, ______, may be milky or clear as glass, while the bluish-green crystal is ______ quartz beryl	

Printed-Verbal

.2.16.2

The crystal with a clear color is ____________

The crystal with a darker color is ____________

Do both have pointed ends and rectangular bodies?

____
(Yes/No)

quartz
beryl
yes

.2.16.3

The quality that distinguishes quartz from beryl is

____
(shape/color)

When we look at crystals of galena and pyrite, we can tell them apart by their ____________
(surfaces/colors)

color
surfaces

The crystal that has a ridged surface is ____________
(pyrite/quartz)

pyrite

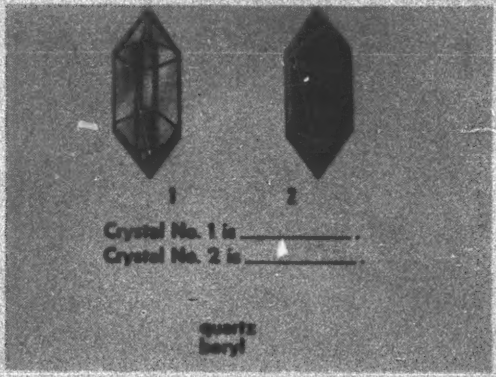
.2.16.5

The crystal mentioned earlier that has a smooth surface and a brownish color is ____________
(galena/beryl)

The crystal with the ridged surface is ____________

galena
pyrite

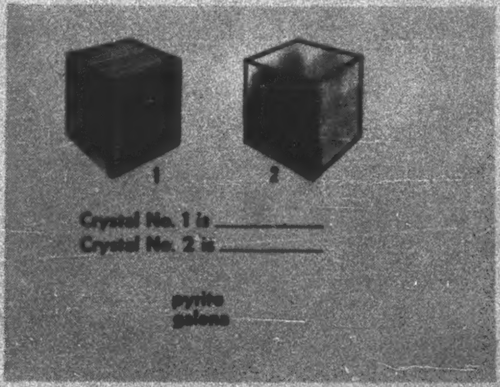
Still-Graphic



Crystal No. 1 is ____________.

Crystal No. 2 is ____________.

quartz
beryl



Crystal No. 1 is ____________

Crystal No. 2 is ____________

pyrite
galena

COMPARISON OF PRINTED-VERBAL AND STILL-GRAPHIC
VISUAL PRESENTATION MODES
IN THE LINEAR PROGRAMING MODE
(Experiment III: Action-Process)

EXPLANATION: The same explanations as given above for the linear programing modes in Experiments I and II pertain here.

Printed-Verbal	**Still-Graphic**
C.S.15 Suppose you dropped a stone in the solution or accidentally knocked the container. Would this affect the movement of molecules in the process of forming a crystal? __________	C.S.15 Suppose you dropped a stone in the solution or accidentally knocked the container. Would this affect the movement of molecules in the process of forming a crystal? __________
C(V)S.15.1 Yes. The crystal growing process would be changed.	C.S.15.1 Yes. The crystal growing process would be interrupted and this is what would take place:

Printed-Verbal

C(V).5.16

Instead of moving toward the crystal seed, the ____________ would collect into a cluster of small imperfect crystals.

molecules

C(V).5.16.1

Sometimes as the molecules are lining up, they suddenly STOP moving toward the crystal seed.

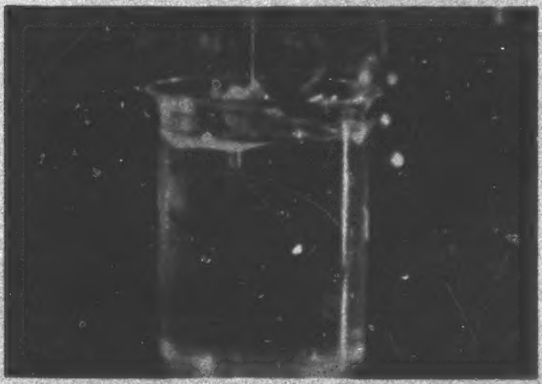
Knocking the container might cause this to happen.

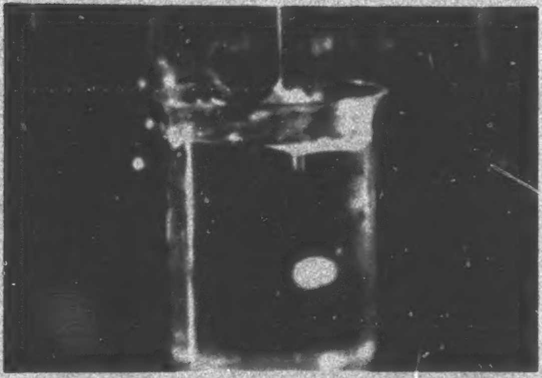
8.6.1(V)

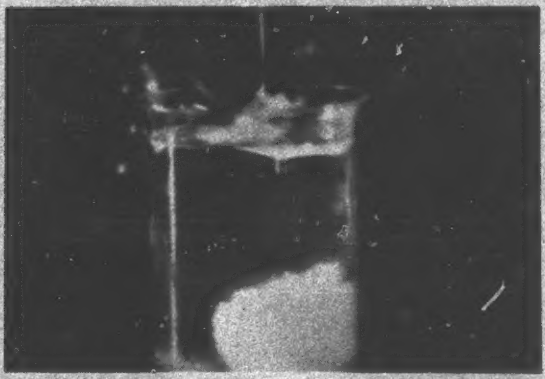
The process we have just talked about is called
SPONTANEOUS NUCLEATION
(Pronounced spon-tay-ne-us nu-clee-a-tion)

Write "spontaneous nucleation" on your paper.

Still-Graphic







8.6.1(V)

The process we have just talked about is called
SPONTANEOUS NUCLEATION
(Pronounced spon-tay-ne-us nu-clee-a-tion)

Write "spontaneous nucleation" on your paper.

Printed-Verbal

II(VI).A.2

Here is a description of what spontaneous nucleation might look like if we could see the individual molecules.

II(VI).A.3

If we could look at the movement of the molecules very closely, we would see them coming together rapidly.

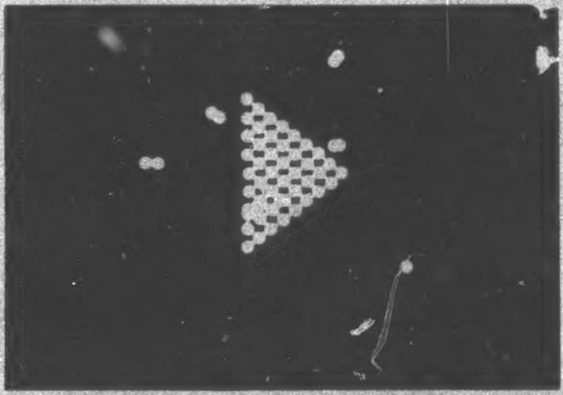
The opposite of normal crystal growth is ______________
(cleavage/spontaneous nucleation)

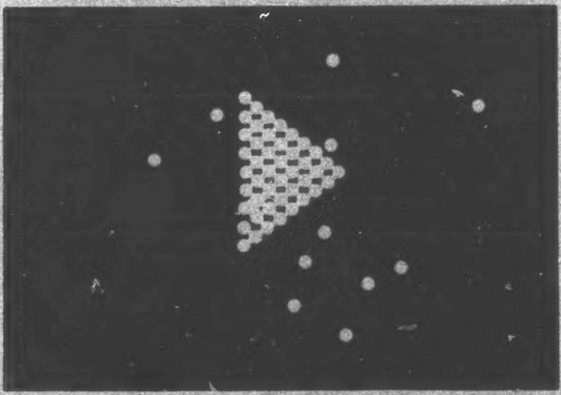
spontaneous nucleation

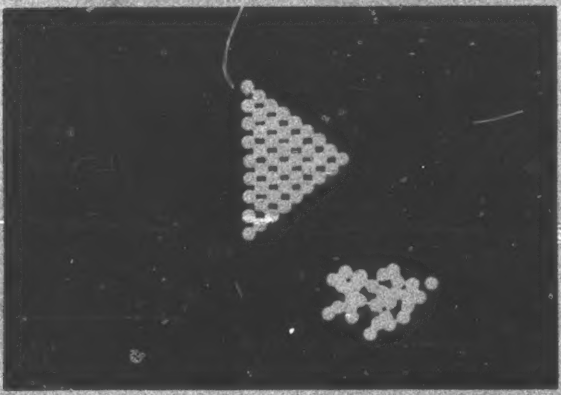
Still-Graphic

II(VI).A.2

Here is a description of what spontaneous nucleation might look like if we could see the individual molecules.







Printed-Verbal

8.A.4

Spontaneous nucleation is the sudden ______________
(coming together/spreading apart)
of the molecules to form small imperfect crystals.

coming together

8(V)A.5

However, if proper conditions are maintained, the crystal seed ______________ grow.
(will/will not)

If this is the case, then spontaneous nucleation ______________ occur.

We will now discuss crystal seeds.

will
will not

8(V)A.6

When many crystals are grown, the seeds are attached to a metal pipe one above the other like branches on a tree and then placed in a solution.

8(V)A.6.1

The crystal seeds are then turned around and around in the solution.

Still-Graphic

8.A.4

Spontaneous nucleation is the sudden ______________
(coming together/spreading apart)
of the molecules to form small imperfect crystals.

coming together

8.A.5

However, if proper conditions are maintained, the crystal seed ______________ grow.
(will/will not)

Then spontaneous nucleation ______________ occur.

You will now see many crystal seeds.

will
will not

Printed-Verbal

8.6.7

Turning the ____________ ____________ also helps the molecules to be distributed evenly on the faces of the crystal seed.

crystal seed

To review, once the molecules start moving toward the crystal seed, spontaneous nucleation may occur because:

(A) the temperature is raised suddenly.
(B) the turning of the crystal seed increases.
(C) the container holding the solution is knocked.

(CHOOSE ONE)

(C) is correct.

Knocking the container may change the movement of the molecules and bring about spontaneous nucleation.

Still-Graphic

8.6.7

Turning the ____________ ____________ also helps the molecules to be distributed evenly on the faces of the crystal seed.

crystal seed

To review, once the molecules start moving toward the crystal seed, spontaneous nucleation may occur because:

(A) the temperature is raised suddenly.
(B) the turning of the crystal seed increases.
(C) the container holding the solution is knocked.

(CHOOSE ONE)

(C) is correct.

Knocking the container may change the movement of the molecules and bring about spontaneous nucleation.

NOTE: Examples of the audio and branching presentation modes for Experiments II and III are not presented because the techniques used for both are similar to those illustrated for Experiment I above.

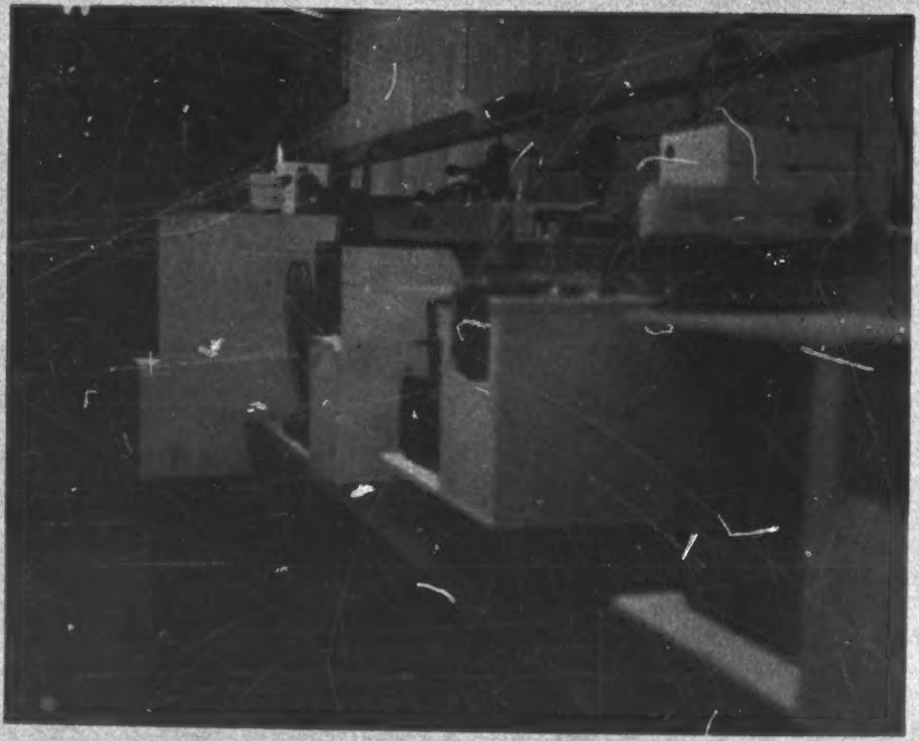
APPENDIX B

THE EXPERIMENTAL APPARATUS

The Experimental Trailer on Site at School

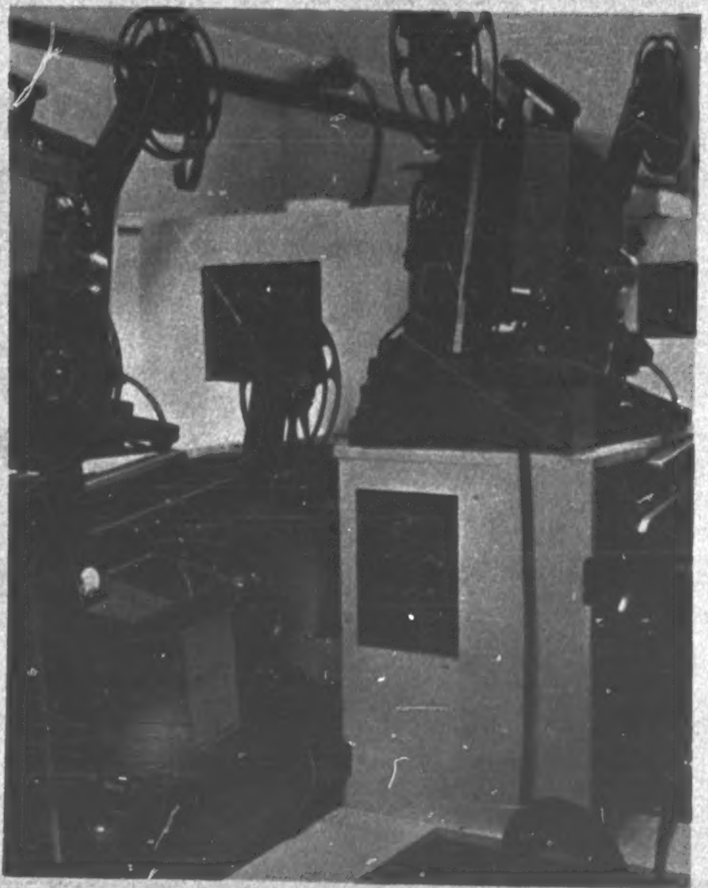
Student Positions
Interior of Trailer

Projection Screen and
Student Response Unit



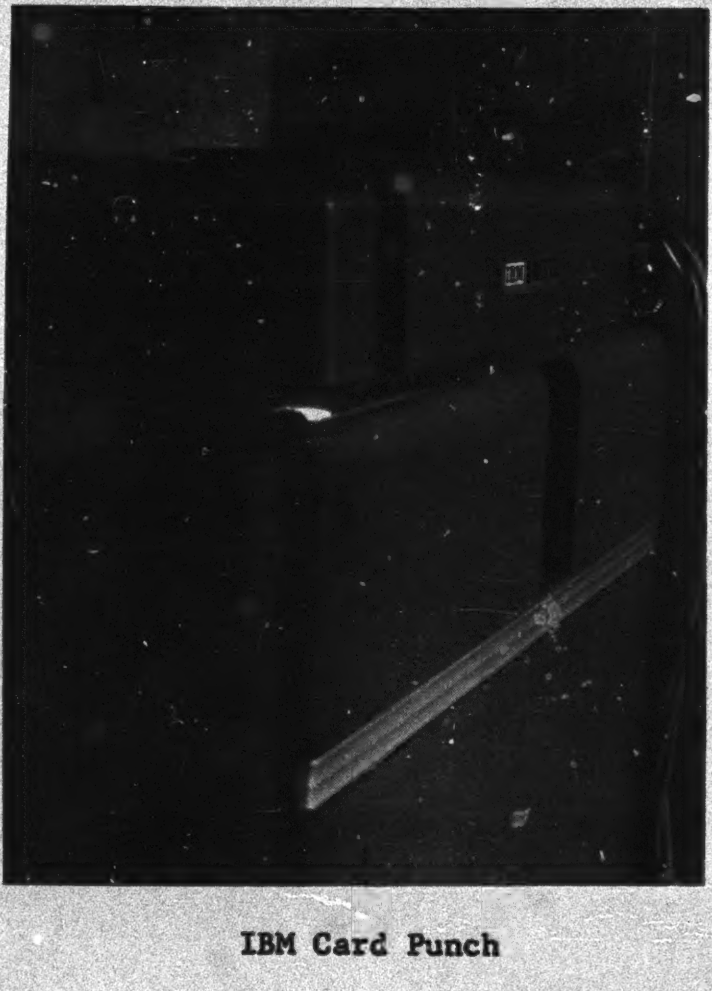
Interior of the Trailer Stimulus Display Area

Still Picture Branching Unit
with Carousel Projecting and
Cousino Repeater Tape Players



Motion Picture Branching Unit
with Sound Motion Picture
Projectors

Monitory and Control Panel



IBM Card Punch

B-4

A Branching Teaching Machine Using Motion Pictures

By DONALD G. PERRIN

A research project at USC required a teaching machine to present sound motion-picture information in a stop-start manner with the capability of branching to different sequences on the basis of the student's response. Four projectors allow immediate access to the branches, while relay logic maintains synchronism between the machines. The unit, which employs standard film production procedures and off-the-shelf equipment, is low in cost and simple to program.

The Cinema Research Division at the University of Southern California has developed a flexible teaching device incorporating sound motion pictures to test new techniques in instruction and communication. The machine is designed for individual instruction, and has immediate access to four channels of information presented on four sound motion-picture projectors. Periodically the projector stops on a question frame which remains until the student responds by pushing a button. Relay logic performs the necessary control functions and keeps the four projectors in synchronism.

The Problem

In February 1963 the University received a United States Office of Education contract to compare visual and audio modes of presenting programed instruction.* Visuals would be print, still graphic and motion-picture, combined with no-sound, redundant or descriptive sound, or directive sound. Each version would be presented as a linear sequence and with the addition of branches — sequences which reteach and supply supplementary information where a student responds incorrectly to a multiple-choice question. Eighteen programs are produced by combining the various modes, and repeating the experiment with three different kinds of subject matter increases the number of programs to a total of 54. All are being produced by the USC Department of Cinema and will be tested on 1,100 eighth-grade students from the Los Angeles City Schools between July and December, 1964.

A Survey of Available Hardware

Linear teaching machines are readily available, but the motion-sound-branching combination seemed likely to pose some problems. The author made national surveys of the teaching-machine field in 1961[1] and 1962–63,[2] and was asked to advise on the needs of the present study.

No existing device met the peculiar needs of the experiment, the most crucial problem being the delay in gaining access to alternate motion-picture sequences. Without the ability to search forward or backward at high speed, the student would spend more time waiting for information to appear than he would watching the program. Figure 1 illustrates the problem. Other major considerations included production cost and special skills needed to program and maintain the machines. Table I lists features of the commercially available units, with details of the author's device for comparison.

Initially the development of a special research instrument was not contemplated, and methods were sought to permit the use of existing equipment. Figure 2 shows a solution where sound and motion are eliminated in the branches. This defeats the purpose of the experiment, which is to compare modes having sound and motion with other less flexible forms of presentation. A compromise measure is suggested in Fig. 3 where a second projector is added to re-teach items which the student answers incorrectly. This allows only one branch, so that questions must be essentially true-false in nature, or multiple-choice items must be broken into a series of two-choice items.

To add a second projector would require extensive redesign of equipment already costing over $5,000 per unit, and the programer would still have only a limited branching capability.

At this point the author suggested a four-projector approach, as shown in Fig. 4, to meet the programing requirements, but since this would require the design and building of a completely new machine, it did not at first seem feasible, even if time and finances were available. But if four off-the-shelf projectors could be sequenced by a black box, the unit might be relatively simple and inexpensive. The machine would include the following components:

(1) four projectors;

(2) relay logic to control functions and sequence;

(3) sensors to read cues on the film;

(4) optical multiplexer to combine images from all projectors onto a single rear-projection screen; and

(5) a student response unit with automated answer tape for written answers, advance button and four multiple-choice buttons.

Searching would be accomplished in advance so that access is reduced from minutes to milliseconds of switching time. Each question can have up to four possible choices, and if the projectors are labeled A, B, C, D, pushing button A will select projector A; button B will select projector B, and so on. Instead of the new information being always on one projector, it is randomized between the four projectors. It was decided that projectors should always move forward, and that backward branching would be better accomplished by periodic review sequences. Also, it would not be necessary to stop on a particular frame since question frames could be repeated for half a foot of film or more. The only real limitation of this particular format

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Presented on April 13, 1964, at the Society's Technical Conference in Los Angeles by Donald G. Perrin, Department of Cinema, University of Southern California, University Park, Los Angeles 7, Calif.
(This paper was received on March 17, 1964.)

* Cooperative Research Project No. 1956, Office of Education, U.S. Department of Health, Education and Welfare, entitled "Visual and Audio Presentation in Machine Programed Instruction," William H. Allen, Project Director.

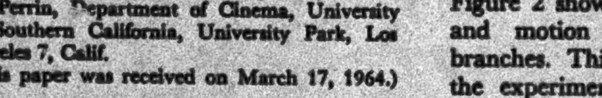

Fig. 1. Serial storage of motion-picture branching items results in long access times. If the chosen answer was D, the access time would be ½ min. If the student then chose answer C (assuming D to be incorrect), it would take the projector a further 70 sec to back up. The same problem would exist for sound reproduction from tape unless a special cuing system was devised to achieve random access at high tape speeds.

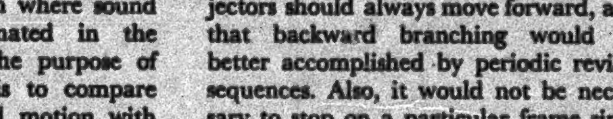

Fig. 2. By eliminating motion and sound in the branches, the problem of access time is overcome, but much of the flexibility in presentation is lost in the process. The program writers rejected this solution because of the need to compare motion with still graphic presentation.

Copyrighted, 1964, by the Society of Motion Picture and Television Engineers, Inc.

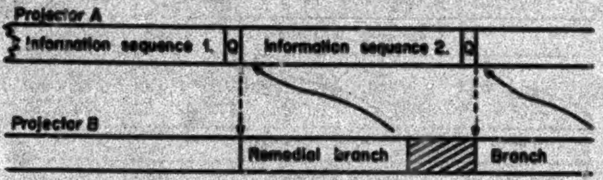

Fig. 3. If all incorrect responses had the same remedial branch, it would be feasible to eliminate the waiting time by using two projectors. This respresents an interesting departure from current practice since searching is accomplished in advance of the question, not after the response. Because this, in effect, limits all questions to true-false types, it was not considered sufficiently flexible.

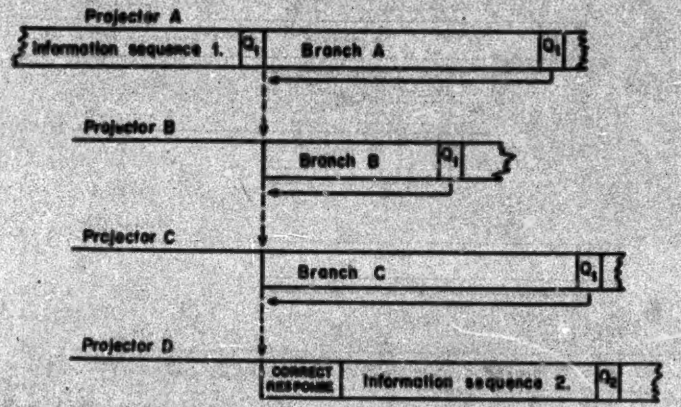

Fig. 4. Four projectors allow a variety of branches with immediate access. When a correct response is made, the projectors not in use search forward to the next multiple-choice question. In the meantime the student receives a new sequence of information on the fourth projector. Branches can now supply remedial information for specific kinds of error.

results when branches are longer than the next information sequence, so that the student has to wait before answering the multiple-choice question until all the projectors finish searching.

The Breadboard Device

Some relay logic was assembled to test the multiple-projector approach, using Carousel slide projectors since these were readily available. A cradle on top of each machine supports two pairs of contacts to read aluminum tabs† on each slide as it drops into the film aperture. Since the slide is lifted slightly as it is advanced, there is a good wipe action to make reliable contact. Figure 5 shows the cradle support and dual contacts. Up to two tabs per projector cue a wide variety of functions including multiple-choice items with two, three or four branches, and also initiate and stop searching at the appropriate times.

It was found that each projector lamp needed to be switched independently since only one projector was showing at any one time. Similarly, the advance and stop mechanisms needed individual control. The device proved remarkably reliable even on its early runs, and the overall simplicity of the approach encouraged its further development. In November 1963, designs were drawn up for four different machines. In the meantime the various components for each version (linear, branching, still–sound and motion) were tested for reliability and compatability. Figure 6 shows the machine requirements.

The Functional Analysis

The breadboard was developed while the programed materials were being written, and functions were changed or added as the programers requested. What seemed a simple logic became unduly complex, with a total of 80 relays

---

† Minnesota Mining Type 425 aluminum tape 5 mil, with pressure-sensitive backing.

Table I. Features of Some Branching Teaching Machines with Motion.

Feature	Chapman Experimental Model	Honeywell Experimental Model	U.S. Industries AutoTutor I	U.S. Industries AutoTutor II	Perrin Research Model
Film size, mm	16	16	35	35	16
Film capacity, ft	1600	800	400	100	4 × 1600
Response features					
No. of multiple choice	4	5	10,000	10	4*
Other buttons	None	Advance, stop, reverse	Motion, still	Reverse	Advance
Automated paper tape (for written answers)	No	No	No	No	Yes
Data recording	Internal computer	External	Time and frame no.	Time and frame no.	Multiple-choice items punched on IBM 523 card punch
Branching capability					
From any one item	10,000 frames	250 frames	10,000 frames	10 frames	4 sequences
Search speed, frames/sec	16†	16†	14†	14†	24‡
Cuing method	Frame count	Address code	Frame count	Frame count	Motion-picture printer cue tabs
Screen blank during search	Yes	No	Yes	No	Yes
Departures from ASA Motion Picture Standards					
Projection speed	16 frames/sec	16 frames/sec	ASA Standard	14 frames/sec	ASA Standard
Frame dimensions	ASA Standard	Reduced to accommodate codings; reversed left to right	Long dimension vertical	Long dimension vertical	ASA Standard
Sound	¼-in. magnetic tape synchronized with pulses	Optical at 16 frames/sec	No sound	No sound	ASA Standard
Approximate cost	$10,000	$8,000	$5,000	$1,200	Under $4,000

* Very few programs use more than four alternatives for multiple-choice items, so that provision for a larger number of choices is not essential.

† Searching is initiated when the student presses the response button, so that search time is determined by the number of frames passed over.

‡ Immediate access is accomplished by searching *in advance*, so that all relevant answer sequences are on stand-by.

Fig. 5. Dual contacts read aluminum tabs on the slide as it is dropped into the projection aperture. Where there are no tabs the advance button lights. The tabs cue multiple choice and search functions.

Fig. 7. "Black box" for the branching machines. The lower chassis switches the 115-v circuits; the remainder of the system operates on 12 v.

in five separate chassis. A functional analysis and redesign reduced the number to 36 for the most complex machine, and to 11 for the simplest. Components are mounted on vector board strips and wired to plugs and relay sockets. The branching machines have three connected chassis, one for power relays and 12-v d-c power supply, the others housing the core logic, cue interpreters and individual projector controls. The completed "black box" is shown in Fig. 7. The logic for the linear machine is housed in a single chassis.

The Sound Motion Picture With Branching

The projector chosen was the Bell & Howell Model 542. It has a reliable solenoid-operated clutch and the switching functions can be rearranged by moving the solderless connectors or by rerouting the circuits through the "black box." Each projector has four operating modes:

(1) advance with lamp and sound off (search mode),

(2) show picture with sound (show mode),

(3) project still picture (question stop), and

(4) projector inactive (on stand-by).

Several cue reading devices were tested to count series of pulses on the film. Microswitches and dragging contacts were rejected because they posed reliability problems, the remaining alternates being r-f cue switches and photoelectric sensors. For counting pulses at the rate of five per second, the Photobell Type RPX2S1 Reflex Photohead reflecting light from aluminum tabs between the sprockets proved very reliable and relatively inexpensive. Up to six tabs in series initiate the various question stops and search functions.

The projection of still frames necessitated slight modification of the projector optics. A 300-w bulb was substituted for the 1,000-w bulb supplied; a dichroic coating on the rear condenser element eliminated some further heat, and an iris in the condenser system increased the depth of focus. The net result was a reduction in light to about 10%, while heat was reduced to less than 1%. There was no noticeable change in focus between still and motion images. The aluminum grill was removed from the fire shutter so that it did not further reduce the light, but a heat-absorbing glass was inserted as extra protection whenever a still frame was projected.

How the Machine Operates

For the basic branching pattern see Fig. 4. When the machine is turned on, the A projector runs and a search cue causes projectors B, C and D to advance to the next sequence start cue. Meanwhile the A projector is presenting sound and picture information with occasional stops for the student to write answers on the automated paper tape. He pushes the advance button to continue, and when the multiple-choice branching item is reached, all the searching projectors are on stand-by. In the example shown all four lights are presented. If the student chooses A, B or C, he receives additional information and the question is re-presented. Pushing D

Minimal machine requirement *

	Linear	Branching
Print	Slides with 1/4" Tape	Slides with 1/2" Tape
Graphics	Slides with 1/4" Tape	Slides with 1/4" Tape
Motion Picture	Sound Motion Picture	Sound Motion Picture

* "No-sound" versions will use the same program and equipment with the speaker turned off.

Fig. 6. If six machines were used in the testing phase, only one would need the branching capability with motion, but two more would need the branching capability with sound.

confirms the correct answer and presents the new information sequence. A new search cue on this causes the remaining projectors to search forward.

There may be only two possible choices, so that only the A and B buttons light up. In most instances there are three or four choices, so that more buttons light up. Suppose that the student chooses A and it is a wrong answer. He is given a special remedial sequence and receives the same question again, but this time the A button does not light, preventing him from making that error a second time. He now makes the correct choice and all machines on stand-by search forward to the next multiplie-choice question. In this instance the A projector will advance just a foot or so since the remedial sequence has already been shown; the other projectors may feed 30 or 40 seconds of film before they are again on stand-by.

It is possible that a student could make two or three errors before finding the right answer, in which case those buttons do not relight when the question is again presented. In general, the branches tend to be much shorter than the information sequences, so there is never a delay in gaining access to branches or right answers. The functions operate similarly on the slide-tape version.

The motion branching device was bulky, but allowed convenient threading space. Figure 8 shows the unit in a near-completed stage. The teaching capability it opens up is discussed in the closing section.

Still-Sound Branching

As mentioned earlier, the problem was not to build a single device but a family of compatible units. The branching programs not involving motion could be presented on the unit described above, but cost is lower for a slide or filmstrip projector as long as reliable synchronization between picture and sound can be achieved. Initially it was intended to go the filmstrip route to achieve rapid film transport, but the reliability of the Carousels decided in their favor. Also, the use of slides is highly advantageous in the development of the program since they can

Fig. 8. Branching sound motion-picture version of the teaching machine. The four projectors are directed into a multiplexer. The machines will be in a room separate from the students, and the screen will be mounted in the dividing wall. In this way students will be less aware of the differences between the machines and the programs.

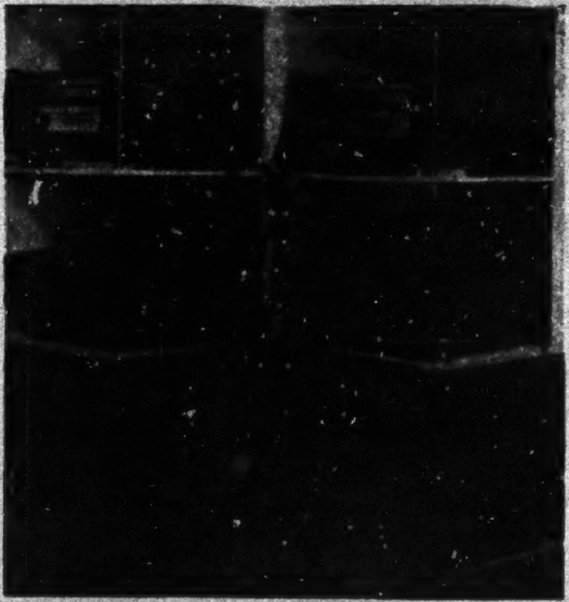

Fig. 9. Equipment used in the Carousel version fits into a more compact module, projectors at the top, "black box" on lower left, and Cousino tape units on lower right.

readily be rearranged or replaced, the tabs can be changed, the sequences can be lengthened and shortened, and so on. This pointed up the inability to pretest programs on the motion-picture devices because of the complex and costly production procedures. The slide–sound device is an inexpensive short cut having all the facilities except motion itself.

The Carousels were synchronized with four Cousino Model R-7320 Repeater Tape Units. Both slides and the tape loop recirculate, eliminating the need for rethreading and synchronizing for each use. The cues were arranged to freeze out all functions at the end of the program until a remote cancel button was pressed by the instructor. The equipment module is shown in Fig. 9.

The Linear Machines

The linear units are quite simple by comparison. A single projector presents the program, and pulses on the film determine which response buttons light and cue the projector to stop. On multiple-choice items there is no remedial sequence for a wrong choice; instead the light in the button is extinguished and the question remains, so that the student has to make a further choice. When the projector does not advance and the remaining response buttons remain lighted, the student knows that his response was wrong. When a correct response is made, the film continues on, the button lights go out and the program confirms the right answer. The slide version works in the same manner.

The logic for the linear machines involves eleven relays. The number of cues on the film is extended to ten pulses for the motion picture, or four tabs on the slides, to accomplish the necessary range of functions.

Data Recording

All machines have outputs to a monitoring panel and an IBM 523 card punch. Additional data from the written answer tape is later transferred to IBM cards for analysis with pre and post test data.

The Ultimate Programing Capability

The final device using branching motion pictures exceeds the capability of the classic teaching machines because of its potential as a simulator for intellectual, decision-making tasks. Motion pictures provide an element of reality sometimes added to computerized simulators such as flight simulators for training pilots. Where decision-making tasks can be reduced to three or four choices at a time, the teaching machine could augment training on the more expensive simulator. For example, the pilot would see his controls and the landing strip on the motion-picture screen. A light flashes on the panel and the frame freezes; the instructor suggests some possible steps: level out, lower the wing flaps, call the tower, put the wheels down. The pilot is unsure and makes a wrong choice. He almost crashes, and receives a special teaching sequence to explain the nature of his error. The problem is then repeated and he is asked to choose again. Other applications would be to train assembly tasks such as building an automobile engine, troubleshooting electronic or other kinds of equipment and teaching procedural tasks such as chemical analysis. Subjective camera viewpoints would show the job being done as if the student were doing it himself. A film allows a repetitive task to be shortened editorially while individual presentation by machine allows the trainee to be corrected before an error is learned.

Acknowledgments

The criteria upon which the machine was developed are essentially those of the USC Cinema Research Staff: William H. Allen, Robert T. Filep and Genevieve S. Gray. The author would like to acknowledge the help and advice of the Honeywell Regulator Company, Robert L. Chapman, Susan M. Markle, William C. Ralke and many others; appreciation is due also to Walt Dailey, Herb Farmer and Dean Luxton for their continued assistance, and to Robert E. Kellam and Ken O'Bryan who assisted in wiring the black boxes.

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APPENDIX C

THE PERFORMANCE POST-TESTS

EXPLANATION: The items of the performance post-tests were presented in printed booklet form, as projected motion picture sequences, and as projected still colored slides (in Experiment II only). The subjects made written responses on answer sheets. The tests are shown below, and the correct answers are indicated in parentheses in the appropriate spaces.

Experiment I: Non-Concrete Referent

Post-Test Questions

1. A solid which has a definite internal order is called a (crystal).

2. Solids which do NOT have definite internal order are called (amorphous) solids.

3. The science of solids with internal order is (crystallography).

4. Write the word that means "like a crystal." (Crystalline)

5. A solid which has a definite internal order is called a

   a) crystel
   b) crystal
   c) cristel
   d) cristal

6. Solids which do NOT have definite internal order are called ________________solids.

   a) amphorus
   b) amourphus
   c) amorphous
   d) amorphious

7. The science of solids with internal order is

   a) crystallography
   b) crystalography
   c) crystellography
   d) cristallography

8. A solid with internal order is called a ______________ solid.

a) crystaline
b) crysteline
[✓ c) crystalline]
d) cristalline

9. If two crystals have the same shape,

a) they belong to the same system.
b) they have the same properties.
c) they are made of the same atoms.
[✓ d) all of these].

10. How many crystal systems are recognized in the science of crystallography?

a) 1
b) 2
[✓ c) 6]
d) 12
e) There is no limit to the number of crystal systems.

11. What determines the shape of a crystal?

a) The kinds of atoms the crystal contains.
b) Whether it is amorphous or not.
[✓ c) The structure of the crystal].
d) Its physical properties.

12. We can be sure that water is not crystalline because

a) it contains only hydrogen and oxygen atoms.
b) it is not an element
c) it is colorless.
[✓ d) it is a liquid].

13. What determines the structure of a crystal?

a) Its shape.
b) Its properties.
[✓ c) The way its atoms are arranged].
d) Whether or not it is a solid.

14. Which of the following is NOT a property of a crystal?

a) Its color.
[✓ b) Its structure].
c) Its hardness.
d) Its weight.

15. If two different crystals belong to the same system, they must have

    a) The same atoms.
    [✓ b) The same properties.]
    c) The same size.
    d) The same shape.

16. Ice is crystalline but water is not. This tells us that when ice melts,

    a) it becomes crystalline.
    [✓ b) the internal order of its atoms changes.]
    c) water has a definite internal order.
    d) ice is an amorphous solid.

17. If two solids are made of the same kinds of atoms, they must have the same shape.

    a) True
    [✓ b) False]

18. Which is more like the atoms in a crystal?

    [✓ a) children marching.]
    b) children playing tag.

18a. If two solids are made of the same kinds of atoms, they must have the same structure.

    [✓ a) True]
    b) False

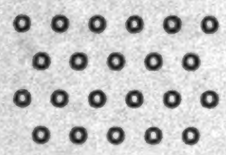
18b. If you wanted to classify some crystals in their proper systems, what would you look at?

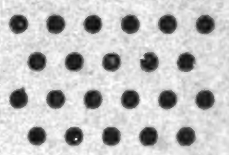
    a) Their physical properties.
    b) Their atoms.
    [✓ c) Their shape.]
    d) Their size.

18c. What do you know about two crystals that have the same shape?

    a) They are the same size.
    [✓ b) They belong to the same system.]
    c) They have the same properties.
    d) They consist of the same atoms.

18d. Here are pictures of the internal structures of two different crystals

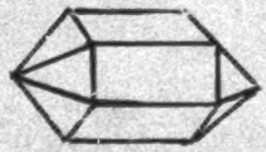


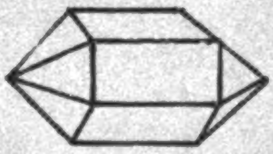


What can you say about these two crystals?

a) They have the same atoms.
b) They have the same properties.
c) They have the same internal structure.
d) They are both amorphous solids.

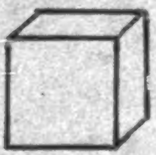
18e. What is certainly true of these crystals?

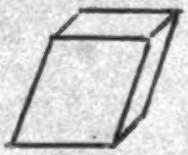


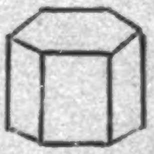


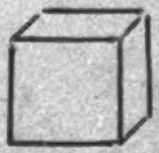
a) They contain the same kinds of atoms.
b) They belong to the same system.
c) They have the same properties.
d) They are both amorphous solids.

19. Suppose you had four crystals and they looked like this:







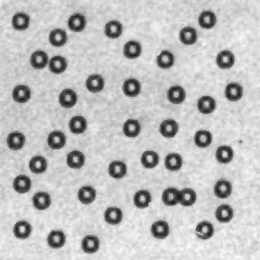


How many different crystals systems could you put them in?

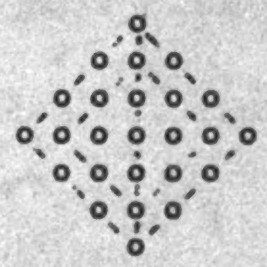
a) 1
b) 2
c) 3
d) 4

19a. Which of these pictures is most like the internal structures of a crystal?

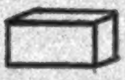
a)

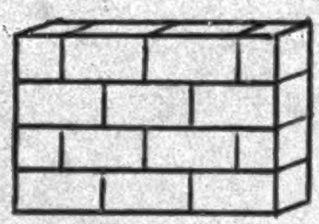


b)



19b.





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0 0 0 0
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0 0 0 0
0 0 0 0 0

BRICK is to **WALL** as ____________ is to **CRYSTAL**.

a) structure
[✓ b) atom]
c) property
d) order

20. On the following pages you will see some questions.

Write an answer for each question. Write the best answer you can.

21. What is a crystal?

22. What is the difference between a crystalline solid and an amorphous solid?

23. What is a crystal system?

24. Name five physical qualities or properties of a crystal.

25. What is crystallography?

STOP. Please wait for further instructions.

FILM TEST (Note: These test items were projected as motion pictures and stopped after each question to give subjects a chance to record answer on answer sheet)

1. The motion picture sequence was animated, showing an irregular shape of black breaking up into three groups, each group being of irregular size but organized into squares, triangles, and rectangles. Printed on the bottom of the frame was the question:

   What word goes with this picture?

   a) atoms b) structures c) systems d) properties

2. The motion picture sequence showed a group of different sizes of balls arranged in an irregular shape. Printed on the bottom of the frame was the question:

   What does this picture represent?

   a) a crystal b) an amorphous solid

3. The motion picture sequence was animated and showed a crystal shape moving to a scale where it was weighed. This was followed by a hammer pounding on another crystal shape and then by a ruler measuring the dimensions of another crystal shape. Printed on the bottom of the frame was the question:

   What word goes with these pictures?

   a) atoms b) structures c) systems d) properties

4. The motion picture sequence showed outline drawings of two crystals, one rectangular and the other of rectangular shape but with one side narrower than the other sides. The shapes were shown in several different positions. Printed on the bottom of the frame was the question:

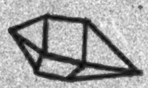
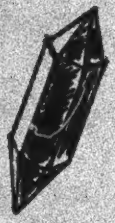
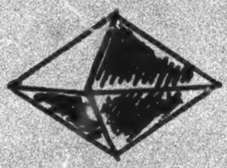
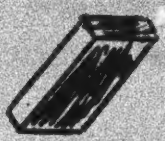
   Could these two crystals belong to the same system?

   a) Yes b) No

Experiment II: Concrete Referent

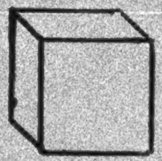
Post-Test Questions

1.

This is a picture of different kinds of (crystals).

2.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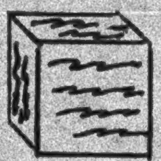
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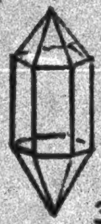
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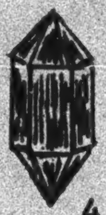
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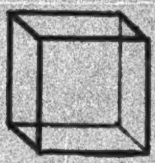
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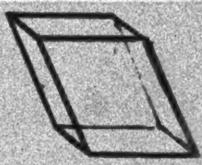
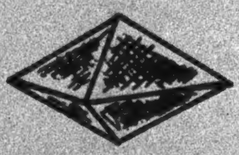
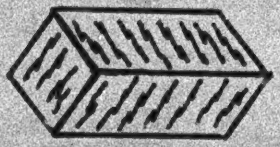
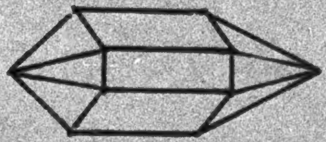

6

Write the names of the six crystals you learned about.

1. (Quartz)
2. (Pyrite)
3. (Galena)
4. (Beryl)
5. (Halite)
6. (Calcite)

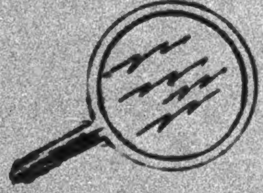
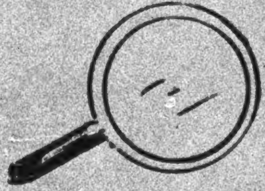
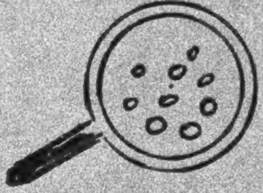
3.

Name three qualities by which you can tell crystals apart.

1. (Surface)
2. (Shape)
3. (Color)

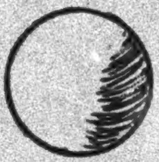
4.

Name three kinds of crystal surfaces.

1. (smooth)
2. (ridged)
3. (rough)

5.



A crystal cannot be sphere-shaped because a sphere does not have

a) color
[✓ b) faces]
c) shape
d) surface

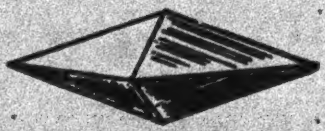
5a. If two crystals have the same shape and color we may be able to tell them apart by their

a) faces
b) edges
c) corners
[✓ d) surfaces]

5b. If two crystals have the same shape, then they must have

a) the same kind of surface
b) the same size
[✓ c) the same number of corners]
d) the same color

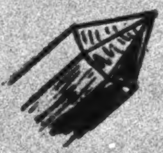
6.



The place where two faces meet is called

[✓ a) an edge]
b) a corner
c) a face
d) a surface

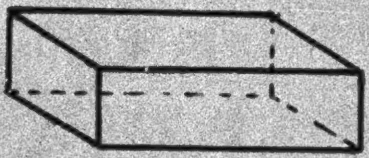
7.



How many faces are needed to make an edge?

a) 1
[✓ b) 2]
c) 3
d) 4

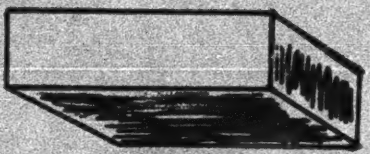
8.



How many faces does this crystal have?

a) 1
b) 4
c) 6
d) 8

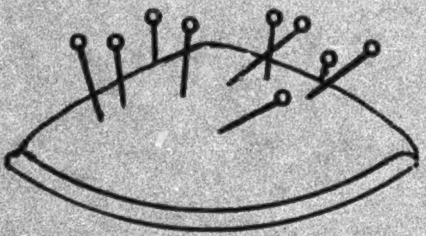
9.



A place where three or more edges meet is called

a) an edge
b) a corner
c) a face
d) a surface

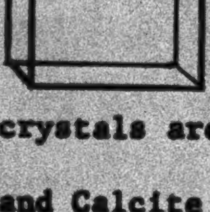
10.

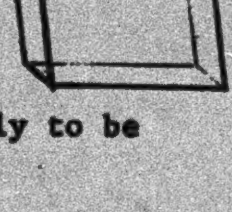


A pin cushion is most like a crystal

a) corner
b) cluster
c) edge
d) shape

11.

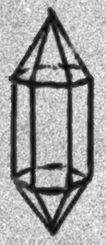


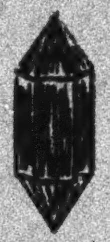


These two crystals are most likely to be

a) Halite and Calcite
b) Galena and Pyrite
c) Quartz and Pyrite
d) Halite and Beryl

12.

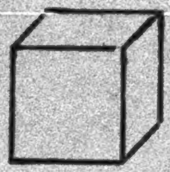


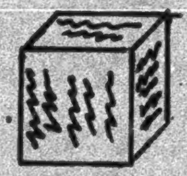


These two crystals are most likely to be

a) Quartz and Pyrite
b) Halite and Beryl
c) Halite and Pyrite
d) Quartz and Beryl

13.

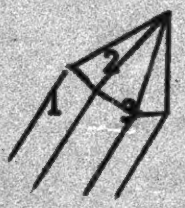




These two crystals are most likely to be

a) Quartz and Beryl
b) Halite and Calcite
c) Galena and Pyrite
d) Quartz and Calcite

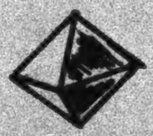
14.

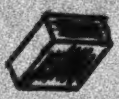


Which letter stands for the correct set of names

a) 1=face, 2=corner, 3=edge
b) 1=corner, 2=face, 3=edge
c) 1=face, 2=edge, 3=corner
d) 1=edge, 2=face, 3=corner

15.

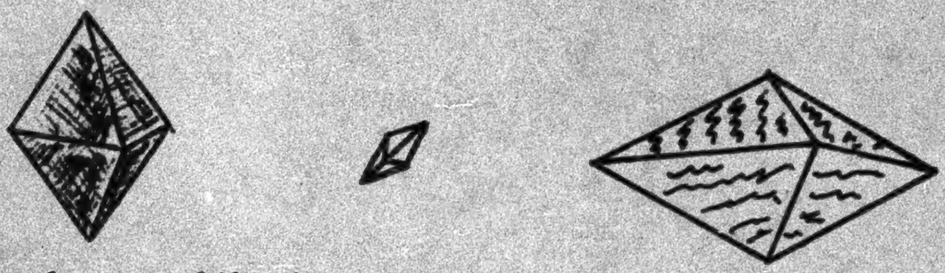




All crystals have

a) clusters
b) glassy surfaces
c) color
d) faces

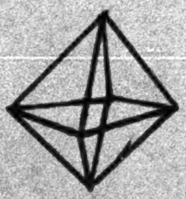
16.



These crystals are alike in

a) color
b) surface
c) shape
d) size

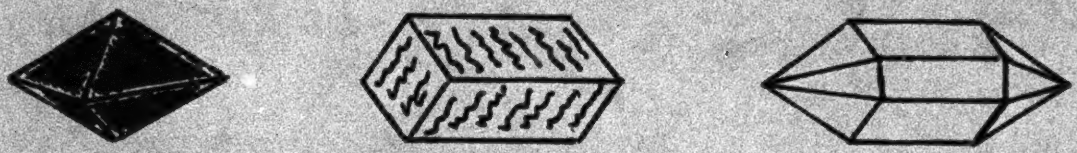
17.



How many corners does this crystal have?

a) 4
b) 6
c) 8
d) 10

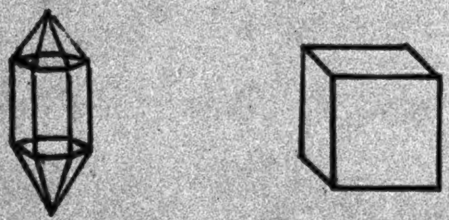
18.



The color, surface, and shape of a crystal are called:

a) Values
b) Faces, edges, and corners
c) Ridged, glassy, and pebbled
d) Features or qualities

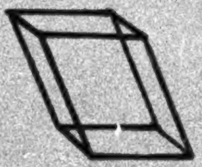
19.

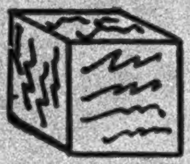


These two crystals are most likely to be

a) Beryl and Halite
b) Quartz and Pyrite
c) Beryl and Pyrite
d) Quartz and Galena

20.

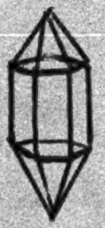


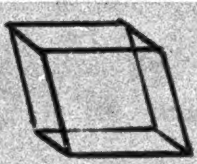


The crystals pictured above are most likely to be

a) Quartz and Pyrite
b) Halite and Calcite
c) Calcite and Pyrite
d) Galena and Pyrite

21.

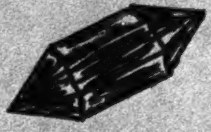


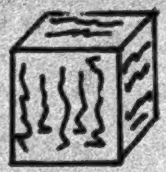


The two crystals pictured above are most likely to be

a) Beryl and Calcite
b) Quartz and Calcite
c) Galena and Halite
d) Quartz and Pyrite

22.





These two crystals are most likely to be

a) Beryl and Calcite
b) Galena and Pyrite
c) Calcite and Quartz
d) Beryl and Pyrite

STOP. Please wait for further instruction.

FILM TEST (Note: These test items were projected as motion pictures and stopped after each question to give subjects a chance to record answer on answer sheet)

1. The motion picture sequence showed the outline form of a crystal shape. The edge lines then popped in darker shade. Then the question and response choices popped in, printed on the bottom of the frame:

   What word goes with this picture?

   a) edges b) color c) surface

2. The following question appeared at the bottom of the frame: What is the smallest number of edges that can form a corner? Then three outline crystal forms popped in above with the edge lines emphasized in black. Then the following response choices popped in:

   a) 1 b) 2 c) 3 d) 4

3. Two shaded crystal forms were shown in the motion picture sequence. Below, the following was printed:

   These crystals have the same

   a) surface

   b) shape

   c) number of faces

   d) color

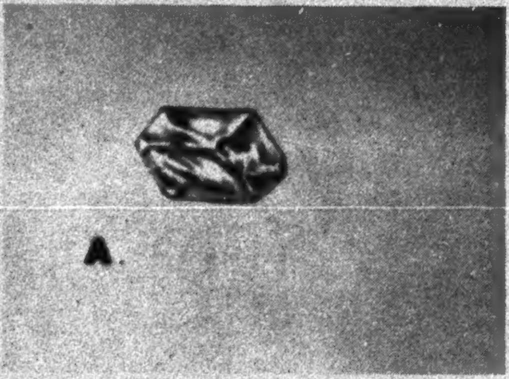
   Then a magnifying glass popped in showing one crystal to have a ridged surface and the other a smooth surface.

4. A number of superimposed pulsating outlines of crystals were shown in the motion picture sequence. The following was printed below:

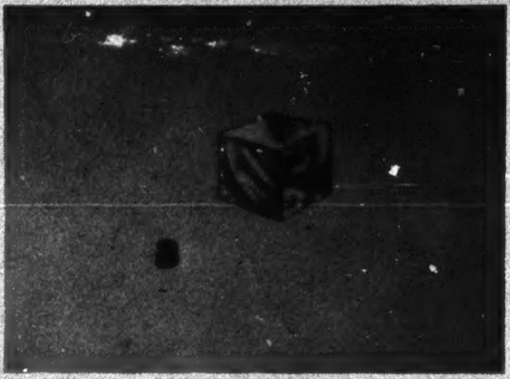
   Some crystals like halite and calcite have no

   a) color b) faces c) edges d) corners

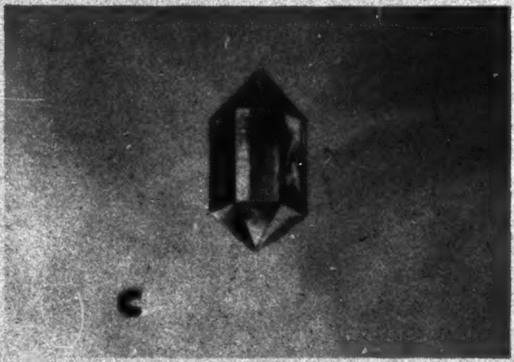
SLIDE TEST (Items 38 to 43 comprise the "identification" sub-test, each slide being projected separately and the subject writing the crystal name. Items 44 to 49 comprise the "matching" sub-test, in this case the subject matching the name with the appropriate crystal picture shown, A, B, C, or NONE.)



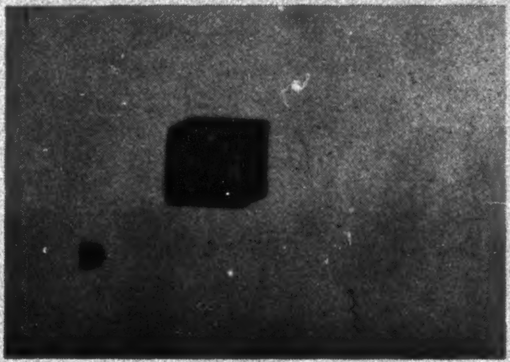
38. Calcite



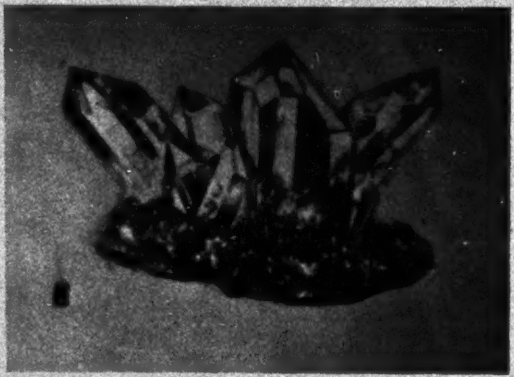
39. Halite



40. Quartz

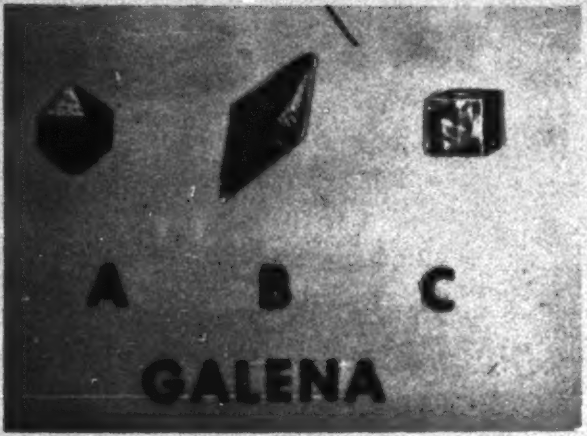


41. Galena

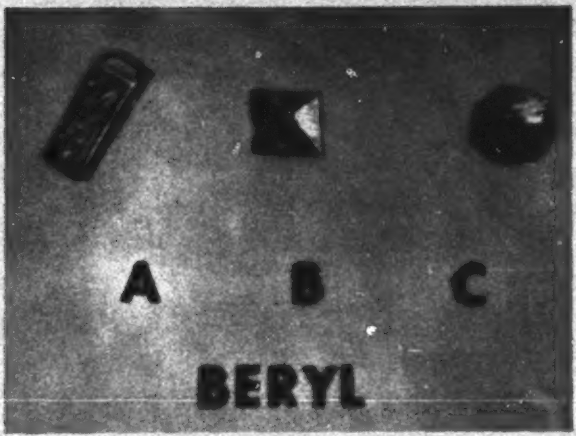


42. (Quartz) cluster

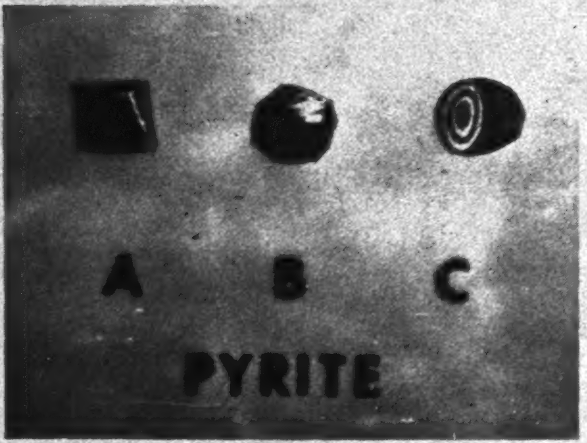
43. (Galena) cluster



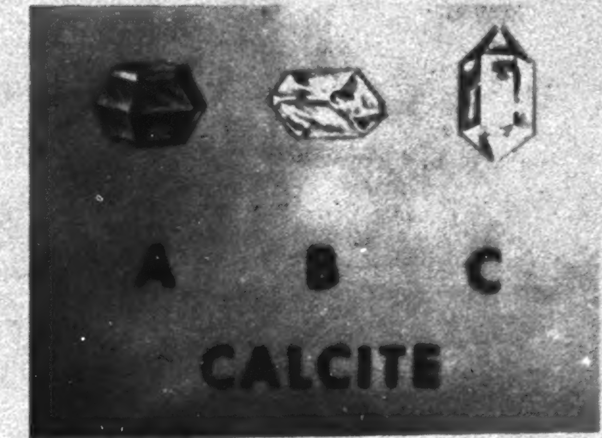
44. A B [✓ C] NONE



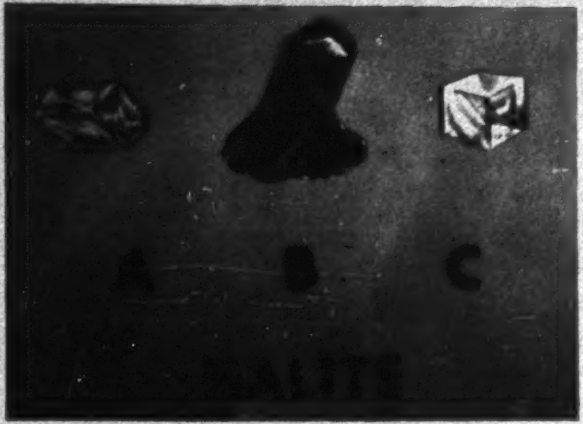
45. [✓ A] B C NONE



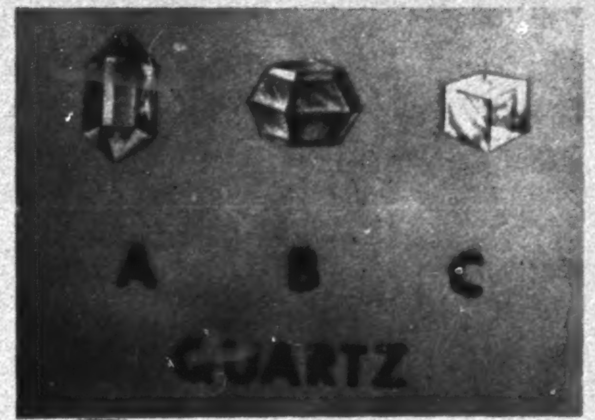
46. [✓ A] B C NONE


A
B
C
CALCITE

47. A [✓ B] C NONE



48. A B [✓ C] NONE



49. [✓ A] B C NONE

Experiment III: Action-Process

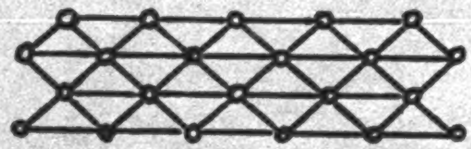
Post-Test Questions

1. When sugar is poured into water the sugar (dissolves).

2. When stirring no longer causes the solid to dissolve in the solution, we call the solution a (saturated) solution.

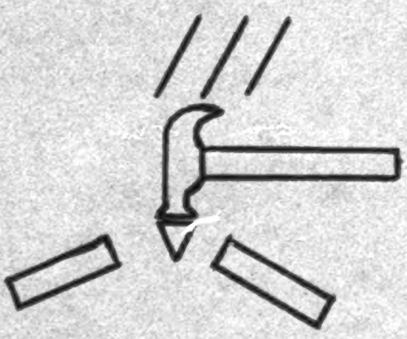
3. Fill in the blank in the following sentence. "From little seeds large (crystals) grow."

4.



The round objects in the picture above represent (molecules) in a crystal.

5.

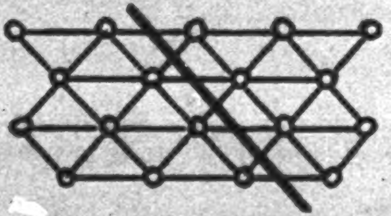


Write the name of the process pictured above.
(Cleavage, Cleaving)

6. List three things that are necessary for crystal growth.

a) (solution)
b) (crystal seed)
c) (heat, molecules, (stirring)

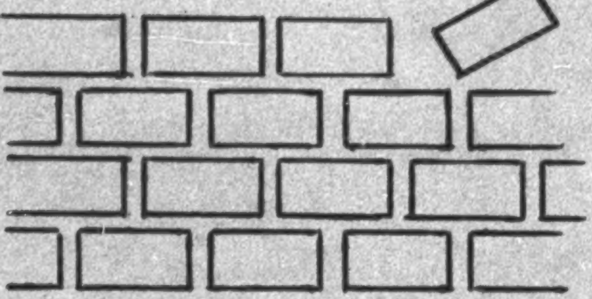
7.

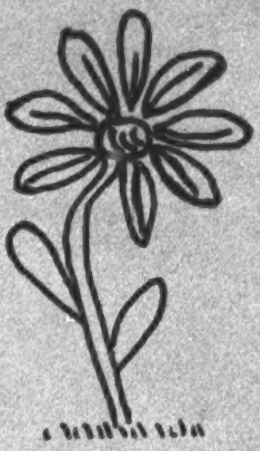


What word goes best with this picture?

a) cleavage
b) solid
c) breaking
d) seed

8\.

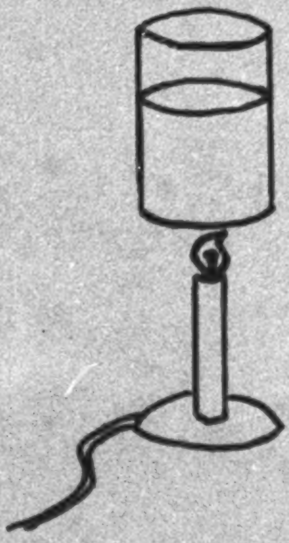




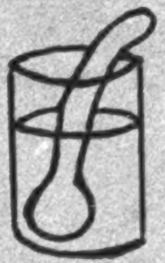
Which is more like crystal growth?

a) growing a flower from a seed.
b) building a wall with bricks.

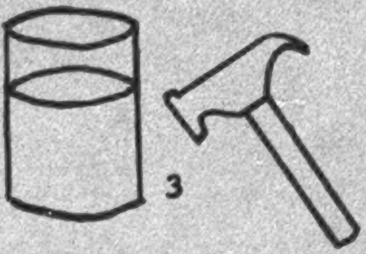
9\.



1



2

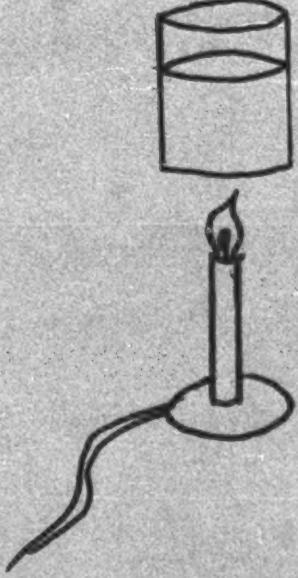


3

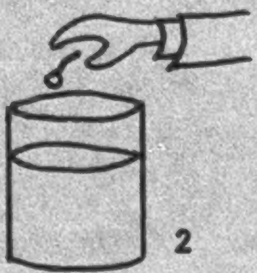
Which picture(s) shows a process that may cause spontaneous nucleation?

a) 1
b) 2
c) 3
d) 1, 2 and 3

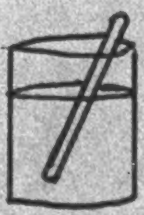
10



1



2

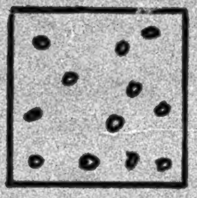


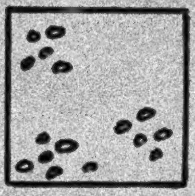
3

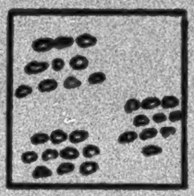
What is the proper order for these three processes in growing a crystal?

a) 1, 2, 3
b) 3, 2, 1
c) 1, 3, 2
d) 3, 1, 2

11.


1

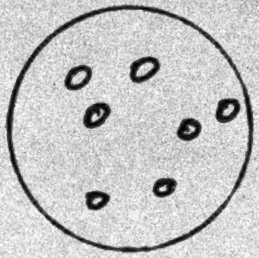

2

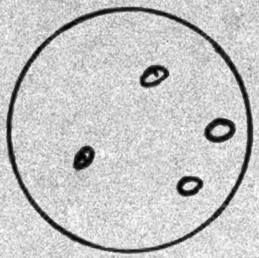

3

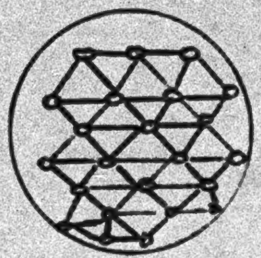
What is the proper order for these pictures if they represent the process of spontaneous nucleation?

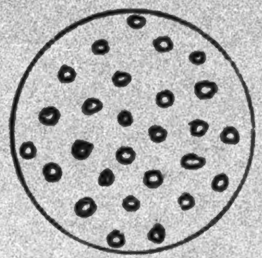
a) 1, 2, 3
b) 3, 2, 1
c) 2, 3, 1
d) 2, 1, 3

12. Which of these pictures is the best representation of the molecules in a super-saturated solution?


(a)


(b)


(c)


(d)

13. Which of the following is most likely to help a crystal grow in an orderly fashion?

a) stirring the solution
b) heating the solution
c) rotating the crystal seed
d) knocking the container

14. What determines how a crystal will split?

a) the number of molecules
b) the speed of the molecules
c) the arrangement of the molecules
d) heating and stirring

15. When molecules in a solution are made to move faster,

a) we can get more molecules in the solution
b) the heat of the solution increases
c) spontaneous nucleation takes place
d) a crystal grows evenly

16. Which of the following is most like cleaving a crystal?

a) breaking a pencil
b) cracking an egg
c) bouncing many balls
[✓ d) cutting a deck of cards]

17. Suppose you have a solution which has fewer molecules than a saturated solution. What will surely happen if you heat it?

a) it will turn into a saturated solution
b) it will turn into a super-saturated solution
[✓ c) the molecules will increase in speed]
d) the molecules will come together rapidly

18. What causes a crystal seed to grow larger?

a) heating a super-saturated solution
b) stirring a saturated solution
[✓ c) molecules attaching to it]
d) spontaneous nucleation

19. What do heating and stirring have in common?

[✓ a) they both increase the speed of the molecules in solution]
b) they both can produce spontaneous nucleation
c) they both cause molecules to attach themselves to a crystal seed
d) they both cause molecules to arrange themselves in an orderly fashion

20. One characteristic of a saturated solution is:

[✓ a) it contains undissolved molecules]
b) it has been heated
c) it contains a crystal seed
d) its molecules move in a regular pattern

21. Stirring sugar in coffee is an example of

a) a super-saturated solution
[✓ b) dissolving a solid in a liquid]
c) growing a crystal
d) seeding a super-saturated solution

22. What will turn a saturated solution into a super-saturated solution?

a) adding a crystal seed
b) stirring the solution
[✓ c) dissolving more molecules]
d) lowering the temperature

23. Which of the following is most likely to cause imperfect crystals to form in a super-saturated solution?

a) heating the solution
b) stirring the solution
c) dissolving more molecules
d) knocking the container

24. Which of the following processes can help to cause more molecules to dissolve in a saturated solution?

a) adding a crystal seed
b) heating the solution
c) adding more of the solid to the solution
d) growing a crystal in the solution

25. The five steps in growing a crystal in solution are given below. They are out of order. Indicate the proper order by writing (1) beside the first step, a (2) beside the second step and etc.

(5) Add a crystal seed
(3 or 2) Stir the solution until no more solid will dissolve
(1) Dissolve the solid in the liquid
(4) Cool the solution
(2 or 3) Heat the solution

26. Explain how you can tell when you have a saturated solution.

STOP. Please wait for further instructions.

FILM TEST (Note: These test items were projected as motion pictures and stopped after each question to give subjects a chance to record answer on answer sheet)

1. The live photography motion picture sequence showed two crystals, one complete and the other cleaved along even planes. A hand picked up parts of the cleaved crystal and turned them in various ways for the viewer to see.

   The phrase that goes best with this picture is:

   a) a crystal may be cleaved along even planes.

   b) "from little seeds large crystals grow."

   c) if proper conditions are maintained, the crystal will grow.

2. The motion picture sequence in live action showed crystals being grown as they revolved evenly in a tank.

   This process should cause

   a) spontaneous nucleation to take place.

   b) even distribution of molecules on crystal seeds.

   c) crystals to cleave evenly.

   d) solids to dissolve in liquids.

3. The animated motion picture sequence showed a mass of balls representing molecules line up in an orderly way and then being connected by a regular gridwork of lines.

   This picture has shown that

   a) lowering the temperature of the solution decreases molecular motion.

   b) crystals grow in a super-saturated solution.

   c) spontaneous nucleation is the sudden coming together of molecules.

   d) molecules in a growing crystal line up in an orderly fashion.

4. The animated motion picture sequence showed molecules represented as solid balls lining up on a regular triangular shape (representing the crystal). Then, suddenly, these balls changed direction and clustered into an amorphous mass.

This sequence represents

a) dissolving a solid.

b) stirring a solution.

c) spontaneous nucleation.

d) heating a solution.

5. The animated motion picture sequence showed a number of round balls in motion. The motion gradually increased in speed until they were moving very rapidly.

What you have just seen shows what happens to molecules in a solution when

a) the temperature of the solution is lowered.

b) spontaneous nucleation takes place.

c) the solution is heated.

d) a crystal grows.

6. The live action motion picture sequence showed a small foreign object (tiny grain) being dropped into a beaker filled with liquid. Midway in its drop to the bottom it suddenly blossomed into a white mass that filled the lower half of the beaker.

What you have just seen is NOT likely to happen if

a) the solution is super-saturated.

b) the molecules are moving rapidly.

c) the container if knocked.

d) a stone drops in the container

7. The live action motion picture sequence showed a man cleaving a crystal with a hammer and chisel into two even pieces. Then he demonstrated a molecular model with balls arranged in even planes. The model was separated into two even parts along planes of the molecules.

This sequence demonstrated that

a) molecular structure determines how a crystal will split.

b) "from little seeds large crystals grow."

c) a crystal cleaves along even planes but a non-crystal does not.

d) spontaneous nucleation is the sudden coming together of molecules.

8. The live action motion picture sequence showed a small molecular model increasing in size.

The phrase that fits this picture best is

a) the arrangement of molecules determines how a crystal will cleave.

b) stirring and heating increase the speed of molecules in solution.

c) spontaneous nucleation.

d) "from little seeds large crystals grow."

APPENDIX D

TABLE 59

EXPERIMENT I CORRELATION MATRIX (N = 388)

		Variables																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Post-Test	(1) Completion Spelling		39	31	51	18	64	14	38	33	27	00	28	18	38	00	15	45	24	39	44	43	43	45	40	49
	(2) Verbal			41	60	25	80	10	41	35	23	03	32	20	35	00	17	49	31	41	44	53	51	46	47	42
	(3) Graphic				46	24	61	13	38	28	27	03	27	18	32	04	13	47	29	44	45	52	43	38	40	35
	(4) Open End					31	90	19	52	38	26	04	35	25	43	06	14	63	38	58	61	67	62	54	52	51
	(5) Film						44	07	27	15	13	00	20	10	20	05	06	35	20	31	32	35	28	25	32	25
	(6) Total Post-Test							19	57	43	31	03	40	28	48	02	18	68	40	63	65	72	66	60	60	58
F Battery	(7) Identical Forms								18	25	26	07	23	30	66	12	09	20	24	25	17	20	22	21	20	14
	(8) Sentence Order									33	24	01	34	25	49	10	12	61	31	53	62	64	53	48	56	52
	(9) Match Problems										28	11	36	33	73	08	12	40	40	46	39	45	48	46	45	27
	(10) Omlet											13	30	24	51	15	07	30	28	34	31	29	29	32	32	34
	(11) Figural Similarities												04	12	29	04	00	03	08	06	07	00	00	04	08	00
	(12) Right Order													30	52	04	16	48	37	49	46	53	52	52	48	37
	(13) Making Objects														68	06	03	32	25	32	34	36	34	27	37	25
	(14) Total F Battery															13	14	51	47	56	50	54	54	51	55	39
	(15) Sex																13	02	12	06	02	05	00	10	28	19
	(16) Age																	34	28	35	20	19	19	18	24	12
CTMM	(17) Language IQ																		51	87	82	82	75	66	69	60
	(18) Non-Language IQ																			87	43	51	52	48	44	24
	(19) Total IQ																				72	76	73	65	65	48
CAT	(20) Vocabulary																					82	72	62	73	66
	(21) Verbal Comprehension																						84	74	77	64
	(22) Reasoning																							81	70	61
	(23) Fundamentals of Mathematics																								70	60
	(24) Mechanics of English																									70
	(25) Spelling																									

TABLE 60

EXPERIMENT II CORRELATION MATRIX (N = 411)

		Variables																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Post-Test	(1) Verbal		61	49	33	42	29	74	16	46	35	20	13	31	23	43	07	19	57	35	53	62	66	62	56	59	46
	(2) Graphic			47	34	55	48	86	10	46	44	28	19	37	22	47	02	24	61	44	58	59	66	63	59	63	52
	(3) Open End				28	40	31	72	12	42	28	33	10	33	22	38	15	20	48	35	47	54	58	51	54	59	58
	(4) Film					30	21	48	11	24	24	17	22	23	21	32	06	11	35	29	36	38	42	38	37	42	29
	(5) Identify						50	72	08	40	27	18	19	32	17	35	00	16	50	35	48	53	49	44	46	49	41
	(6) Spot If There							63	03	32	18	13	08	20	12	23	04	17	36	22	32	35	37	34	32	36	33
	(7) Total Post-Test								14	55	43	32	19	42	27	53	07	26	69	47	55	72	75	70	58	73	63
F Battery	(8) Identical Forms									13	22	23	04	15	23	59	14	04	20	25	25	23	19	21	20	26	12
	(9) Sentence Order										34	24	23	38	30	55	04	24	62	41	59	63	66	56	54	59	51
	(10) Match Problems											23	24	37	31	75	09	07	40	44	47	39	46	45	45	42	25
	(11) Omlet												19	37	14	48	08	17	40	34	42	39	38	41	42	42	38
	(12) Figural Similarities													13	21	41	10	02	16	18	20	21	14	13	15	18	05
	(13) Right Order														31	53	01	20	48	40	50	43	48	52	51	46	41
	(14) Making Objects															62	00	08	29	28	33	34	30	33	31	35	24
	(15) Total F Battery																02	14	56	54	63	59	59	59	58	61	41
	(16) Sex																	15	07	15	13	01	03	04	03	18	29
	(17) Age																		42	39	46	27	28	27	26	29	34
CTMM	(18) Language IQ																			54	89	83	83	79	70	74	64
	(19) Non-Language IQ																				86	47	55	56	58	52	38
	(20) Total IQ																					75	79	77	73	72	59
CAT	(21) Vocabulary																						84	76	71	79	68
	(22) Verbal Comprehension																							85	78	83	69
	(23) Reasoning																								85	77	64
	(24) Fundamentals of Mathematics																									78	65
	(25) Mechanics of English																										75
	(26) Spelling																										

D-2

TABLE 61

EXPERIMENT III CORRELATION MATRIX (N = 433)

		Variables																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Post-Test	(1) Verbal		58	53	33	56	39	91	17	49	40	27	16	30	22	45	04	31	66	43	63	57	66	60	49	56	45
	(2) Graphic			38	27	48	37	78	16	46	33	30	14	25	21	41	00	24	54	37	52	45	55	51	45	51	42
	(3) Open End				26	40	28	62	10	37	38	22	14	25	17	38	04	25	51	34	49	39	50	49	39	45	35
	(4) Sequence					22	15	39	08	20	15	08	07	11	04	17	06	05	20	19	16	17	24	21	17	19	19
	(5) Film						30	74	18	50	34	24	12	27	19	42	02	29	54	38	53	49	56	51	42	48	43
	(6) Solution							52	14	33	18	22	15	10	22	30	17	19	34	20	31	33	35	29	27	35	28
	(7) Total Post-Test								21	58	44	33	18	33	26	53	05	34	71	47	68	62	72	66	55	64	52
F Battery	(8) Identical Forms									19	34	24	04	11	19	64	18	12	19	25	25	19	15	17	21	25	08
	(9) Sentence Order										32	21	17	33	22	51	13	32	62	40	58	56	63	55	49	57	52
	(10) Match Problems											30	25	32	28	77	01	16	38	45	48	32	41	45	43	46	21
	(11) Omlet												22	29	23	53	17	23	40	32	41	36	36	39	36	39	36
	(12) Figural Similarities													19	24	42	01	10	18	19	21	16	17	18	19	18	11
	(13) Right Order														26	48	01	23	40	44	48	33	40	41	37	36	28
	(14) Making Objects															63	01	14	25	29	31	20	22	24	18	24	18
	(15) Total F Battery																11	27	52	54	61	46	50	52	49	55	34
	(16) Sex																	07	07	04	02	13	10	07	13	25	28
	(17) Age																		51	38	51	41	41	36	33	41	40
CTMM	(18) Language IQ																			52	87	80	82	75	64	73	62
	(19) Non-Language IQ																				87	45	54	56	55	51	35
	(20) Total IQ																					72	78	75	68	71	56
CAT	(21) Vocabulary																						78	67	57	72	68
	(22) Verbal Comprehension																							84	74	80	67
	(23) Reasoning																								83	75	62
	(24) Fundamentals of Mathematics																									77	60
	(25) Mechanics of English																										70
	(26) Spelling																										

P3

OE 6000 (5-65)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION
WASHINGTON 25, D.C.

ERIC DOCUMENT RESUME

DATE OF RESUME

1. ACCESSION NO.
2. ERIC SATELLITE CODE
3. CLEARING HOUSE CONTROL NO.

4. SOURCE
University of Southern California

5. TITLE
Visual and Audio Presentation in Machine Programed Instruction
(Project No. 5-0724-2-12-1 Final Report.)

6. AUTHOR(S) Allen, William H., and Others

7. DATE Jan. 1967
8. PAGINATION 227p
9. REFERENCES 131 ref.

10. REPORT/SERIES NO. N.A.

11. CONTRACT NO. OE-3-10-084

12. PUBLICATION TITLE
N.A.

13. EDITOR(S) N.A.

14. PUBLISHER N.A.

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15. ABSTRACT *(250 words max.)*

Study comprised three parallel experiments, each involving inherently different subject matter content (non-concrete referent, concrete referent, action-process) and each utilizing a 3x3x2 experimental design combining three visual presentation modes (printed-verbal, still-graphic, motion picture), three audio presentation modes (silent, redundant sound, directive sound), and two programing approaches (linear, remedial branching). Study used 54 programed instructional sequences on general science topic "Crystallography," presented individually to Ss by specially designed teaching machines housed in a trailer. Subjects were 1238 eighth graders from Los Angeles Unified School District, randomized to treatments. Performance was measured by knowledge post-tests, a measure of figural ability, a semantic differential scale, and student response data. Analysis was by correlation analysis, factor analysis, analysis of variance and covariance, Scheffé's test, and t-test. Results: (1) The learning of content having concrete referents was increased significantly by supplementing printed programed sequences with still or motion pictorial illustrations. (2) No significant differences were found for non-concrete or action-process content, audio presentation modes, programing approaches, learner characteristics, time taken to complete programs, or response error rate. (3) There was a tendency for each visual presentation group to perform best on subtests similar in form to stimulus mode received.

16. RETRIEVAL TERMS *(Continue on reverse)*

Programed instruction
Teaching machines
Motion pictures
Print
Learner characteristics
Audio presentation
Content inherency

Linear programing format
Branching programing format
General science content
Response error rate

17. IDENTIFIERS